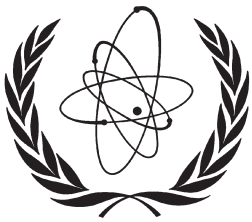

THE ANNUAL REPORT FOR 1999

INTERNATIONAL ATOMIC ENERGY AGENCY

GC(44)/4

MEMBER STATES OF THE
INTERNATIONAL ATOMIC ENERGY AGENCY

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BURKINA FASO
CAMBODIA
CAMEROON
CANADA
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CUBA
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DEMOCRATIC REPUBLIC OF THE CONGO
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UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
UNITED REPUBLIC OF TANZANIA
UNITED STATES OF AMERICA
URUGUAY
UZBEKISTAN
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ZAMBIA
ZIMBABWE

The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

NOTE

NOTE

- Article VI.J of the Statute requires the Board of Governors to submit "an annual report to the General Conference concerning the affairs of the Agency and any projects approved by the Agency". This report covers the period 1 January to 31 December 1999.
- All sums of money are expressed in United States dollars.
- The designations employed and the presentation of material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.
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- The term "non-nuclear-weapon State" is used as in the Final Document of the 1968 Conference of Non-Nuclear-Weapon States (United Nations document A/7277) and in the Treaty on the Non-Proliferation of Nuclear Weapons.
- Further information on the Agency's activities, and on the range of available databases, can be obtained from the Division of Public Information and from the Agency's Internet home page:

  http://www.iaea.org/worldatom

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ABBREVIATIONS

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ABACC	Brazilian–Argentine Agency for Accounting and Control of Nuclear Materials
AFRA	African Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology
AGRIS	Agricultural Information System
ARCAL	Regional Co-operative Arrangements for the Promotion of Nuclear Science and Technology in Latin America
BWR	Boiling water reactor
CRP	Co-ordinated Research Project
CTBTO	Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization
EURATOM	European Atomic Energy Community
FAO	Food and Agriculture Organization of the United Nations
FORATOM	Forum atomique européen
HWR	Heavy water reactor
IAEA-MEL	IAEA Marine Environment Laboratory
ICTP	International Centre for Theoretical Physics
IIASA	International Institute for Applied Systems Analysis
ILO	International Labour Organisation
IMO	International Maritime Organization
INDC	International Nuclear Data Committee
IOC	Intergovernmental Oceanographic Commission (UNESCO)
ISO	International Organization for Standardization
LWR	Light water reactor
NEA	Nuclear Energy Agency of the OECD
OECD	Organisation for Economic Co-operation and Development
OLADE	Organización Latinoamericana de Energía
OPANAL	Organismo para la Proscripción de las Armas Nucleares en América Latina y el Caribe
PAHO	Pan American Health Organization/WHO
PHWR	Pressurized heavy water reactor
PWR	Pressurized water reactor
RAF	Regional Africa
RAS	Regional East Asia and Pacific
RAW	Regional West Asia
RBMK	Light boiling water cooled graphite moderated pressure tube reactor (former USSR)
RCA	Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology
SQ	Significant quantity
t HM	tonnes heavy metal
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
WCO	World Customs Organization
WEC	World Energy Council
WHO	World Health Organization
WTO	World Trade Organization

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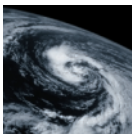
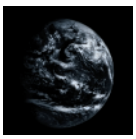
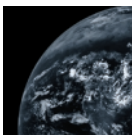
CONTENTS



THE AGENCY'S PROGRAMME IN 1999



Technology



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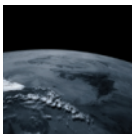


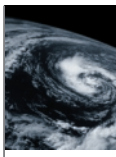
Verification

Management and Outreach

OVERVIEW

In 1999, the Agency Secretariat continued the reform process intended to ensure more effective delivery of a programme that would make a clear contribution to the needs of Member States. In particular, a Medium Term Strategy (MTS) was developed and changes to the programme and budget formulation process were initiated. Programme activities continued under all three of what the MTS identified as the "pillars" of the Agency's programme: *technology*, *safety* and *verification*. Measures were introduced to increase the synergy between the parts of the programme funded by the regular budget and the technical co-operation budget.

This overview is intended to provide a review of issues and developments in 1999 in the 'nuclear world' as seen from the perspective of the Agency and in the light of the Agency's own programme. It does not aim to be comprehensive. Rather it follows a number of selected themes: the present situation regarding nuclear power; the advantages of nuclear related techniques in food and agriculture, human health, water resources management and environmental monitoring; the Agency's efforts to create a global nuclear safety culture; the efforts to conclude Additional Protocols to safeguards agreements and move to integrated safeguards; outreach to non-traditional partners; and gaining a better understanding of the needs of Member States and ensuring a more efficient and effective response to them.



TECHNOLOGY

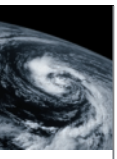
Nuclear power, fuel cycle and waste management

Present situation regarding nuclear power

Nuclear power is an important contributor to the world's electricity needs. In 1999, it supplied roughly one sixth of global electricity. As a capital intensive and advanced technology, some 83% of global nuclear electricity capacity is concentrated in the industrialized countries. The largest regional percentage of electricity generated through nuclear power last year was in western Europe (30%). The nuclear shares in France, Belgium and Sweden were 75, 58 and 47%, respectively. In North America, the nuclear share was 20% for the USA and 12% for Canada. In Asia, the figures were 43% for the Republic of Korea and 36% for Japan.

Despite this major contribution to regional as well as national electricity supply worldwide, there is no consensus on the future of nuclear power. In North America there have been no new orders for nuclear power plants during the past two decades and the number of operating reactors has started to decline. In Western Europe nuclear capacity will likely remain at about its present level for the next few years. There will be some unit capacity upgrades and life extension of existing plants. No country within this geographical area has currently decided to construct new nuclear plants, although Finland is considering this option. In Central and Eastern Europe, there is a debate over the need to complete the construction of partially built plants. A few will be completed and ageing units shut down, some earlier than originally planned.

"Notable features of recently built nuclear plants, particularly standardized ones, include considerably shorter construction times and lower operating costs."



In Asia, planning for an expansion of nuclear power continues, particularly in China, India, Japan and the Republic of Korea. This is a region where the use of nuclear power is likely to grow over the short term. However, the East Asian financial crisis of 1998–1999 slowed down the large regional increase in energy demand that was earlier foreseen.

Any expansion of the contribution of nuclear power towards meeting global energy needs in a sustainable manner will require a number of criteria to be met: increased economic competitiveness; the use of advanced technologies for both electricity generation and new applications such as desalination; and improvement of public confidence, especially in relation to the safety of power plant operations and waste disposal.

During the past decade, fundamental changes in the electricity industry have taken place in many countries. Today, the supply of electricity is no longer a monopoly of governments or a few suppliers. Generation and marketing to final consumers are taking place in highly competitive environments. In 1999, the trend continued for short term pricing contracts to replace long term contracts, driven in part by the availability of low cost gas generating plants.

To compete with fossil fuelled units — and especially small gas units where an investment can often be recovered more rapidly than for a nuclear plant — nuclear power would need to offer lower initial investment costs and a reduction in operating and maintenance expenses. An integrated planning process that takes account of all these factors from the inception of a nuclear power programme can help efforts in this direction.

Notable features of recently built nuclear plants, particularly standardized ones, include considerably shorter construction times and lower operating costs. A number of factors account for this improved performance, including ongoing utility restructuring that includes modernized management approaches, in-depth training and the sharing of industry experience. The steady performance improvement worldwide over the past decade can be seen in various indicators released by the Agency and WANO that show sharp increases in capacity factors and decreases in unplanned reactor shutdowns.

Moreover, many existing nuclear plants are economic, particularly those which have had their capital investments depreciated or written-off. Today, with the exception perhaps of hydroelectric plants, well managed nuclear plants, with their low fuel costs and steadily declining operating and maintenance costs, are often among the least expensive power plants to operate. This advantage has been sufficient to encourage owners of existing plants to invest in life extension programmes and increases in total plant generating capacity. Competitive pressures and the ongoing restructuring of the power industry hold the potential for further cost reductions, particularly in consolidating management, operation and maintenance activities.

For both existing and new nuclear power plants, the Agency has assisted Member States to enhance competitiveness with due regard to safety. For example, it has provided analyses and expertise and assembled and made available information on reducing initial costs, extending plants lifetimes, improving performance and decreasing operational and maintenance costs.

At the 43rd regular session of the General Conference in 1999, Member States requested the Agency to help countries assess the role of nuclear power in the light of global environmental challenges and energy needs. It was agreed that such assistance should include facilitating access to relevant information about the importance of nuclear power in achieving sustainable development in developing countries and in mitigating greenhouse gas emissions.

The Agency made concerted efforts to provide information to Member States and international forums on the potential role of nuclear power in a follow-up to the Kyoto Protocol on climate change. As a part of this effort, three workshops were held on the potential role of nuclear power under the Clean Development Mechanism (CDM). It also included exchange of views with delegates to the 5th Conference of Parties (CoP-5) to the United Nations Framework Convention on Climate Change, in Bonn, and presentation of a paper on the potential use of nuclear power projects in developing countries for greenhouse gas mitigation under the CDM at an international symposium held in Ottawa, Canada.

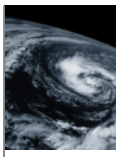
Two potential future applications of nuclear power are of particular interest: desalination and synthetic fuel production. A comprehensive study, co-ordinated by the Agency, on the overall economics of nuclear desalination as compared with the use of fossil energy was conducted. The results highlighted the conditions under which nuclear desalination would be competitive with fossil alternatives. Conclusions were derived both from calculations performed with the Agency's Desalination Economic Evaluation Programme computer software as well as from independent investigations in Member States.

In connection with synthetic fuels, an Agency CRP completed in 1999 provided supporting technical information for the High Temperature Engineering Test Reactor now undergoing startup testing in Japan. The project focused on using nuclear heat for steam reforming of methane to produce hydrogen and methanol, thermo-chemical splitting of water to produce hydrogen and the conversion of coal to synthetic fuels.

Although competitiveness may be one of the important factors in the nuclear debate, public acceptance is also critical. A change from generally positive to generally negative attitudes occurred in different countries for a variety of reasons. Decision makers were once prepared to accept technical arguments for nuclear power and technical safety assessments of reactors and waste disposal facilities. Now some have taken an anti-nuclear position and others have recognized that even where there are technically acceptable plans they still cannot proceed without winning public acceptance.

With regard to the nuclear fuel industry, an increase in fuel burnup, higher thermal rates, longer fuel cycles and the use of mixed oxide (MOX) fuels are key to improving the economics of the nuclear fuel cycle as a whole. Accordingly, utilities and fuel vendors have recently initiated R&D programmes directed towards improvements in fuel design and materials to provide safe and reliable reactor operation under the conditions mentioned above. In conjunction with these programmes, the Agency concentrated in 1999 on facilitating the exchange of information on improvements in the quality and properties of uranium dioxide and MOX fuels and control rods, improvements in fuel design and performance for high burnup operation, reduction of corrosion, and coolant technology optimization. An international symposium on MOX fuel cycle technologies for medium and long term deployment, held in Vienna in May, reviewed the status and development trends of plutonium recycling in nuclear power reactors.

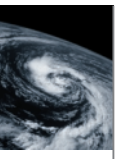
Numerous lessons emerged from the accidents at Three Mile Island and Chernobyl. It was clear that human factors had been a major



contributor to both accidents, and a better understanding of the human role in plant operation was needed. The industry has responded and continues to respond through modernized control room layouts that provide clear and essential information to operators, through improved training and procedures, as well as through internal and external audits of operational performance.

The Agency has a broad range of technical programmes covering reactor engineering and technology that allow the sharing of information on improving and monitoring plant performance and on advanced reactor technology developments and their applications. Nevertheless, the only clear and convincing demonstration of safety will be the safe performance of existing plants across the world over many years, and the avoidance of a major accident.

"The Agency has a broad range of technical programmes covering reactor engineering that allow the sharing of information on improving and monitoring plant performance."



A serious public acceptance issue today is the management of radioactive waste and spent fuel. While a major benefit of nuclear power is that it does not involve the emission of large quantities of air pollutants, including greenhouse gas emissions, it has a unique perception problem with regard to waste disposal, namely the widespread belief among the non-technical public that spent fuel and high level radioactive waste cannot be safely managed *in the long term*. However, managing these forms of waste in the short term while supervision can be guaranteed does not pose a problem and storage facilities for them have been built. At both power plants and research reactor sites, spent fuel can be safely and reliably stored in wet or dry facilities, although some storage facilities for spent fuel are now at or near full capacity. For the longer term, however, it is generally recognized that deep underground disposal is the most appropriate solution.

Plans for geological repositories in many countries proceeded slowly if at all in 1999. Many States are re-examining national policies, seeking to identify waste management solutions that are both safe and publicly acceptable, and to build confidence in those solutions. For example, greater attention is being given to the idea of placing waste deep underground but in a retrievable form, rather than treating geological disposal as a permanent, irreversible solution. It is now recognized that the trust of the public has to be obtained through continuous dialogue and exchange between all concerned parties so that it eventually becomes recognized that geological disposal is a safe and sound solution.

However, some progress was made in the field of radioactive waste management in 1999 *(see Box 1)*. In particular, an important step was taken in the USA with the opening of the Waste Isolation Pilot Plant for long lived, military origin waste at Carlsbad, New Mexico. This is the world's first deep geological waste repository.

RADIATION AND ISOTOPE TECHNOLOGIES

Advantages of nuclear related techniques in food and agriculture, human health, water resources management and environmental monitoring

In the Agency's Medium Term Strategy developed during the year, priority in the radiation and isotope technology programme was assigned to four subject areas: food and agriculture; human health; water resources management; and the environment. The present text describes some of the advantages of nuclear techniques in these areas and outlines some advances that occurred in 1999 (*see also Boxes 2–4*).

For food and agriculture, the advantages of nuclear techniques include: the provision of unique and quantitative data on rates of soil

erosion and nutrient and water dynamics in the soil–plant system; the possibility of developing, through mutation induction, new crop varieties with improved quality, yield and tolerance to stress; and the provision of essential tools for the analysis and identification of plants with useful characters. In animal health studies, isotopes can be used as simple, robust and sensitive markers for research.

They provide unique information on how feed is digested and used, enabling better diets and feeding strategies to be developed. In addition, isotope techniques have underpinned innovative products and approaches to improve reproductive efficiency and disease control. In pest management, the sterile insect technique offers clear advantages over chemical pesticides. And food irradiation is one of the few technologies which offers the ability to control spoilage and disease causing organisms and insect pests without significantly affecting the sensory and other attributes of the food.

In December 1999, the United States Department of Agriculture gave approval for the irradiation of red meat. At the end of the year several commercial irradiation facilities were under construction in the USA to treat large volumes of meat, especially ground beef, to eliminate pathogenic bacteria such as *E. coli*. A commercial irradiator specifically designed for treating fresh fruits and vegetables against fruit flies was under construction in Hilo, Hawaii, and is expected to be in operation by June 2000. These examples illustrate a positive trend in public opinion on the role of

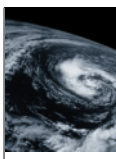
Box 1: **Availability of Waste Management Technologies and Need for Geological Repositories**

A symposium was held in Taejon, Republic of Korea, in August–September to review experience gained in implementing technologies to manage radioactive waste from nuclear power plants and the back end of the nuclear fuel cycle. The symposium was organized in co-operation with the OECD/NEA, the Korea Atomic Energy Research Institute, the International Union of Producers and Distributors of Electrical Energy, and the Nuclear Energy Institute. The symposium documented that:

- Proven technologies exist for managing low level radioactive wastes in ways that are safe, economical and environmentally sound, and considerable experience has been accumulated with these technologies in many Member States.
- More attention to waste minimization and volume reduction technologies have led to substantial reductions in the quantities and radioactivity content of solid wastes.
- Improvements continue to be made in the technologies for the treatment and conditioning of radioactive wastes, and in the methods that are used to investigate and select sites for waste disposal.
- Member States have a variety of options still under consideration for the management of high level waste and spent fuel, including long term storage of spent fuel, until the preferred disposal option becomes more clear.
- A few Member States with large nuclear programmes are making progress in developing concepts for siting disposal facilities for high level waste.

A conference held in Denver, USA, in November demonstrated that Member States are implementing a variety of options for managing spent fuel and high level waste. It was reported that:

- The USA, Sweden and a few other countries are opting for direct disposal but with more reliance on extended retrievability.
- France, Japan, the Russian Federation and the United Kingdom view spent fuel as a resource and are reprocessing spent fuel to recover plutonium for recycle in light water reactors as MOX fuels.
- A number of countries are investigating the partitioning and transmutation of long lived actinides to reduce the volume and activity of the waste.
- Other countries, particularly those with small nuclear programmes or fragile economies, are storing spent fuel, either in pools at reactors or in centralized facilities. ■



food irradiation. They also complement the ongoing work of the Agency in disseminating information to the public concerning the safety and benefits of food irradiation.

Reflecting the continuing trend in the use of radiation mutation to produce crop varieties with characteristics of economic importance, 93 new varieties were registered in the FAO/IAEA database. The total number has grown to 1961 varieties of more than 163 crop species in 62 countries. In related work through a CRP, radiation mutation of industrial crops (such as soybean, rapeseed and cotton) produced plant types with a wider range of desirable characteristics, specifically improved yield and oil quality. These plant types are expected to be released in the near future as new, improved varieties in several Member States.

Box 2: Zanzibar Farmers Reap Benefits Following Eradication of the Tsetse Fly

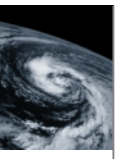
A team of agriculture/livestock economists concluded that eradication — under an Agency project — of the tsetse fly from Zanzibar, United Republic of Tanzania, using the sterile insect technique has resulted in significant gains in the livestock sector. Animals can be kept in farming areas where this was not possible before, and the elimination of trypanosomosis transmission permits the introduction of more productive cattle breeds. According to the report, whereas in 1985–1986 only every third farming household had cattle, in 1999 four of every five farmers were keeping cattle. Although more than one third of the total milk production in Zanzibar now originates from improved cattle breeds and there is substantial demand for cross-bred or pure-bred cattle among the people on Zanzibar, only about 5% of the cattle being maintained are improved breeds. On the basis of baseline data generated by the economists, it will be possible to assess how much of the new potential for livestock/agricultural development, which is based on the elimination of the tsetse and trypanosomosis problem, will be realized in the forthcoming years. ■

Hydrological applications of isotope techniques have gained worldwide prominence in recent years and are being used for a wide spectrum of problems encountered in water resources assessment, development and management. The technological and economic benefits of isotope applications have been demonstrated in many areas of hydrology.

Isotope techniques are an important tool also for understanding and reconstructing climatic conditions influencing the present and past hydrological cycles. General circulation models for simulating present day climatic conditions are improved by using data on the isotope composition of water in rain and snow. Periodic events such as El Niño produce significant, short term changes in precipitation patterns, and their impact on water resources management is being investigated by isotope techniques. Stable and radioactive isotopes also provide a unique tool for investigating the sources of atmospheric pollutants and their contribution to global warming.

Groundwater resources in most developed countries are commonly assessed with the use of isotope techniques. As an example of recent work, an improved assessment of the origin of flow in streams and rivers has been achieved in Latin America, Asia and Africa under Agency technical co-operation projects by using isotope techniques. In other work, it has been found that increased river discharge is responsible for the rising water level of the Caspian Sea as a result primarily of changes in the hydroclimatic conditions in the catchment area.

Another area of focus during recent years has been isotope applications in geothermal systems related to both the hydrological assessment of geothermal reservoirs as well as the characterization of dynamic changes induced in such reservoirs by exploitation. As a result of the experience and data gathered in practical applications of tracers/isotopes in geothermal applications under a regional technical co-operation project and a CRP, a guidebook has been prepared entitled *Isotopic and Chemical Techniques in Geothermal Exploration, Development and Use: Methods, Data Handling and Interpretation*.



In 1999, meetings were held with World Bank project managers to investigate dam management problems, and help Bank staff improve risk assessment tools and identify priority areas for isotope investigations. The resulting 'Thematic Plan on Dam Safety and Sustainability' identified goals and clarified the role of nuclear techniques in dam management as generating information to help end-users make decisions that guide, optimize and protect investments. A particular follow-up action was the organization in November of a training workshop on the use of isotope hydrology for dam safety and dam leakage studies, hosted by BATAN in Yogyakarta, Indonesia.

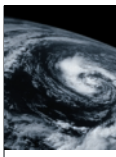
Applications of nuclear related techniques for human health are expanding. Most important is the radiation therapy of cancer as a curative technique and for pain relief in cases that are incurable. Another example is in diagnostic procedures under the broad heading of nuclear medicine. These procedures involve the administration of open radioactive sources internally which, being non-invasive in nature, provide important clues about organ functions and early detection of abnormalities. These diagnostic procedures support a broad span of medical specialities ranging from paediatrics to cardiology to psychiatry. A third area of application is the measurement of stable isotopes in tracking malnutrition, generally considered to be the best method for assessing the impact of people's intake of important vitamins and other nutrients. In all these three broad areas there have been significant Agency activities geared to Member State needs.

New options were recently introduced to study tissue viability by means of three dimensional imaging (tomography) of chemical processes. Another new approach involves localization of pathological processes even during the course of surgery. Positron emission tomography (PET) has increasingly been adopted in many developed and some developing countries for the diagnosis of a significant number of diseases including cancer, neurological disorders and coronary artery disease. The inauguration of a PET centre, supported by an

Box 3: **Importance of Food Irradiation**

The role of irradiation as a sanitary and phytosanitary treatment of food and agricultural commodities was highlighted at an FAO–IAEA–WHO conference on Ensuring the Safety and Quality of Food through Radiation Processing, held in Antalya, Turkey, in October. Among the main conclusions were the following:

- The safety and nutritional adequacy of foods irradiated with any dose and produced under good manufacturing practices are well established.
- The Codex Alimentarius Commission of the FAO/WHO Food Standards Programme has agreed to initiate procedures to amend the current Codex General Standard for Irradiated Foods to remove the previous upper dose limit.
- Irradiation has emerged as a viable, versatile and environmentally friendly treatment of food and agricultural commodities to satisfy relevant provisions of the Agreement on the Application of Sanitary and Phytosanitary Measures of the World Trade Organization.
- Irradiation should be considered as an integral part of efforts to ensure the microbiological safety of solid foods, especially those eaten raw or minimally processed, and to prevent cross-contamination during food preparation.
- Market trials and commercial sales of irradiated food carried out in the past ten years in some 15 countries have shown that consumers are willing to purchase irradiated products once they are informed of their safety and benefits.
- Irradiation is used routinely for ensuring the hygienic quality of spices and dried vegetable seasonings in more than 20 countries.
- A number of commercial irradiators for food processing have either been built in recent years or are being built, especially in the USA and in some Asian countries. ■



Agency technical co-operation project, in the Czech Republic in November marked an important landmark in this context. A major Agency activity in the field of radionuclide therapy included the promotion in Member States of treatment for metastatic bone pain by injection of open radioactive sources for temporary relief.

Radiation therapy over the last decade has increasingly used computer tomography scanning and magnetic resonance imaging for improved tumour definition for the localization of cancer. More accurate display of cancer tumours has increased the accuracy of systems, delivered under Agency technical co-operation projects, for patient immobilization and planning of treatment so as to ensure that the irradiated part of the patient only minimally exceeds the tumour boundary.

Box 4: Use of Isotope Techniques to Help Understand the Causes of Lake Level Rise in Ethiopia

The water level of Lake Beseka, located in the Ethiopian Rift Valley, has been rising continuously for several decades, resulting in the present surface area of about 40 km^2 as compared with 6 km^2 in 1967. The increased surface area has posed serious problems for environmental management, including inundation of grazing and cultivated lands, highways and railway tracks. Historically, the lake received recharge from precipitation, surface runoff in the catchment, groundwater discharge and surface runoff from nearby thermal springs. As the lake level has risen, the thermal springs are now submerged. A study conducted in the 1970s attributed the rising lake level to increased runoff from adjoining irrigated areas. However, stricter controls on irrigation runoff failed to check the rising lake level.

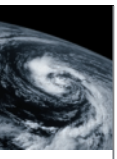
A multi-disciplinary study, including geophysical, hydrological, geochemical and modelling techniques, was carried out in 1999 to determine the cause(s) of the lake level rise. The results of early surveys had suggested that the principal cause may be the increased inflow from submerged springs in the southwestern portion of the lake. However, stable water isotopes, tritium and carbon-14 of dissolved inorganic carbon provided conclusive evidence that the lake level rise occurred as a result of a decrease in the lake outflow. ■

Environmental contamination is a global concern. The Agency carries out monitoring of marine radioactive contamination and also of non-nuclear contaminants in the marine environment (in collaboration with UNEP and IOC (UNESCO)). The behaviour of radionuclides in the ocean needs to be clearly understood to assess the possible environmental or human health consequences. This accumulated knowledge could then provide a basis for the rapid assessment of the impact of any possible future releases from accidents that might occur at coastal nuclear facilities or nuclear waste sites, or from the ocean transport of spent fuel or high level waste.

New remote measurement systems and wide ranging measurements in the world's oceans in 1999 continued to provide confirmation that global fallout from atmospheric bomb testing is still the main source of anthropogenic radionuclides in the ocean, although levels have declined substantially. Radionuclides have also been used to trace the transport of various pollutants (e.g. lead, persistent organic pollutants, etc.) within the ocean and through the marine food chain.

The radiation of electron beams provides an efficient technology to clean gaseous and liquid wastes from industries. A large project in Poland on the cleaning of flue gases from the burning of coal will result in the commissioning of a demonstration plant in 2000.

Again, in the sphere of environmental protection, technical and economic considerations have indicated that electron beam accelerators are most suited for the treatment of large quantities of water and wastewater. In addition, improvements in accelerators in recent years (increased power conversion efficiency and power output) have increased the practical possibilities of using this technology for the decontamination and desinfection of wastewater and drinking water. Following an Agency CRP, a number of countries have started engineering studies of the process.



SAFETY

International dimensions of safety

The Agency promotes a global nuclear safety culture comprising three elements: legally binding conventions, internationally agreed safety standards and measures to apply those conventions and standards. There were a number of significant events and issues from 1999 relating to these three elements (*see also Box 5*).

The Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency were adopted following the 1986 Chernobyl accident. In 1999, the Agency provided assistance to four Member States in relation to emergency situations.

The Convention on Nuclear Safety, which entered into force in October 1996, encourages countries with nuclear power plants to legally commit themselves to maintaining a high level of safety. As well as imposing obligations concerning specific issues such as the siting, design, construction and operation of nuclear power plants, the Convention obliges Contracting Parties to periodically submit reports on the implementation of the obligations for peer review at meetings of the Parties. The first of these review meetings was held in Vienna in April. During the two week meeting, the Contracting Parties reviewed each national report, along with questions and comments that had been submitted. A consensus Summary Report was adopted, outlining the main conclusions from the discussions and the issues identified as being important for future progress in improving nuclear safety. The Contracting Parties agreed that the review process had been of great value to their national nuclear safety programmes, referring not only to the 'peer review' by other Contracting Parties, but also to the self-assessment involved in producing the national reports. Although there were variations among Contracting Parties with regard to the levels from which they started implementation of Convention obligations

Box 5: **An Action Plan for the Safety of Radiation Sources**

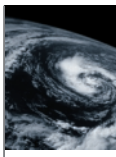
In recent years there have been a number of instances of serious consequences resulting from radiation exposures due to radiation sources and radioactive materials that, for one reason or another, were not under proper control ('orphan sources'). During 1999, the Agency was involved in responding to serious cases of overexposure from such sources in Turkey and Peru, and it continued to provide assistance to Georgia, where many sources have been discovered since the breakup of the Soviet Union.

In response to the continuing occurrence of such events, an Action Plan on the safety of radiation sources and the security of radioactive material was prepared. This sets out a programme of Agency work in the coming years that makes full use of existing activities such as the technical co-operation Model Project on strengthening radiation and waste safety infrastructure where necessary in Member States, and work with the WCO and INTERPOL on the prevention, detection and response to illicit trafficking. The main regulatory components of the Action Plan comprise Agency activities aimed at:

- Strengthening national regulatory programmes covering the safety of radiation sources and the security of radioactive materials, and the storage or disposal of disused sources;
- Detection and emergency response; and
- Recovery and remediation.

Training is an essential part of all these activities. Supporting components of the Action Plan are aimed at persons or organizations having an interest in seeing that the problem of orphan sources is addressed. These include metal recyclers, metallurgical plants and non-radioactive waste disposal facilities. The manufacturers and suppliers of monitoring or detection systems also form part of this group.

The Action Plan was endorsed by the General Conference in October. ■



and in the resources available for improvement programmes, it was noted that all Contracting Parties participating in the meeting are taking steps in the right direction.

During 1999, eight more countries ratified the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, bringing the total number to 13. The convention requires ratification by 25 countries to enter into force, 15 of which should be countries with operating nuclear power plants.

On 30 September, a criticality accident occurred at a uranium conversion facility in Tokaimura, Japan. A self-sustaining nuclear fission chain reaction (criticality) began spontaneously in a precipitation tank after several times more than the specified limit of a solution of enriched uranium had been added. Criticality continued intermittently for about 20 hours, until it was stopped by draining water from the cooling jacket around the precipitation tank and adding boron to the solution. Three workers who were in the building at the time criticality was reached suffered acute radiation sickness as a result of exposure to intense direct radiation (mainly neutrons) from the precipitation tank; one died on 21 December and another was still in hospital as of the end of 1999. Seven people working just outside the site and other people living within a 350 m zone around the location received doses above the annual limit for the public. Precautionary measures around the site were taken. In view of the severe on-site impact and the absence of any significant release of radioactive material off-site, the accident was rated at Level 4 on the International Nuclear Event Scale (INES), the highest rating since the scale was introduced in 1990.

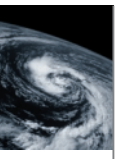
"An increasing amount of the Agency's safety related work is concerned with strengthening national regulatory bodies."

The Agency established contact with the relevant competent authority in Japan to ascertain the facts in order to respond to the many requests for information. Following discussions with representatives of the Government of Japan, the Agency sent an expert team to Tokaimura in mid-October to conduct a preliminary fact finding mission. The report of the expert team was published shortly after its return.

An investigation committee, established by the Nuclear Safety Commission of the Japanese Science and Technology Agency, issued its report in December. An underlying cause of the accident was a lack of awareness of the risk of criticality, which allowed the direct cause — violation of procedural regulations — to occur. The allocation of authority and responsibility between the Nuclear Safety Commission, the regulatory authorities and the operator was a contributory factor.

The accident also highlighted the lack of international safety standards for certain types of non-reactor facility, particularly in relation to criticality safety at these facilities. This lack had already been recognized, and a programme of work proposed to identify new standards that might be necessary.

Improving the safety of reactors in central and eastern Europe and the former Soviet Union has been a major objective over the past decade. An International Conference on Strengthening Nuclear Safety in Eastern Europe, held in Vienna in June, provided an opportunity to review what has been achieved and what remains to be done. The conference, organized by the Agency in co-operation with the European Commission and the OECD/NEA, involved presentations by all of the countries operating Soviet type reactors — Armenia, Bulgaria, the Czech Republic, Hungary, Lithuania, the Russian Federation, Slovakia and Ukraine — on their national status and plans. The conference concluded that considerable progress had been made, particularly in areas such as national legislative and regulatory frameworks and the independence and technical competence of nuclear regulatory bodies. A number of areas were identified as needing further attention,



including the enforcement authority of regulatory bodies, transferring appropriate responsibilities for safety to the operators and maintaining and enhancing an effective safety culture. Particular emphasis was placed on means for achieving the best possible improvements in safety with limited resources, such as greater exchange of information, and high quality safety analysis reports to provide a sound basis for prioritizing upgrades.

An increasing amount of the Agency's safety related work is concerned with strengthening national regulatory bodies. Regulatory issues are also a major focus of the programme on the safety of nuclear installations in countries in South East Asia, the Pacific and Far East (including States that currently have no nuclear power plants but are considering the nuclear power option). For the first time, the Agency's International Regulatory Review Team (IRRT) service received requests from Member States in western and northern Europe. The scope of the IRRT service has also been broadened to cover, if requested, radiation, radioactive waste and transport safety.

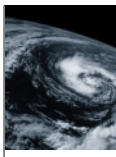
In recent years, regulators have increasingly felt a need to demonstrate the effectiveness of their activities. The Agency has started work on the development of tools for the assessment of regulatory effectiveness. New Agency safety standards on legal and governmental infrastructure for safety could be used as a basis for developing self-assessment tools for regulatory bodies.

A new service, the Transport Safety Appraisal Service (TranSAS), was introduced by the Agency to provide reviews, on request, of national implementation of the Regulations for the Safe Transport of Radioactive Material. The first TranSAS mission visited Slovenia in June/July and carried out an appraisal of the: legislative framework for the transport of radioactive materials and the associated division of responsibilities among competent authorities; approval procedures; and inspection and emergency preparedness arrangements. With the agreement of the Slovenian authorities, the mission report was presented to the General Conference in September. In Resolution GC(43)/RES/11, the General Conference encouraged Member States "to make use where appropriate of the Transport Safety Appraisal Service with a view to achieving the highest possible levels of safety during the transport of radioactive materials".

In a preliminary review to begin work on safety standards for the geological disposal of radioactive waste, the Agency's Waste Safety Standards Advisory Committee identified the areas of international consensus, as well as those areas in which expert opinion has not yet converged. Countries attending an International Conference on Geologic Repositories organized by the US Department of Energy in Denver, issued a joint declaration outlining areas of agreement. And an Agency conference in Córdoba, Spain, in March 2000 provided another opportunity to help develop consensus.

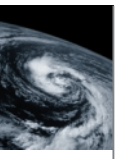
The issue of residual wastes — radioactive residues from past activities such as the testing of nuclear weapons or the mining and processing of metal ores — has become prominent in recent years. Some consensus on appropriate safety principles and criteria is gradually emerging: for example, new recommendations of the International Commission on Radiological Protection on the treatment of prolonged (chronic) exposure situations were approved in 1999 and will be published in 2000. To contribute towards consensus, and to disseminate information on national and international experience, the Agency organized a symposium in Arlington, USA. Discussions confirmed that diverse policies have been and are being adopted in affected countries. The meeting served to initiate exchanges on the reasons for these differences in approach and represented a step towards international convergence.

Residues of particular concern to a number of Member States are those from uranium mining and milling: these typically have relatively low concentrations of radionuclides, but the radionuclides are extremely long lived and the wastes can occur in very large amounts. The management of such wastes was the issue in Agency missions to Brazil and Tajikistan.



The Agency undertook a substantial special project to assist Member States in addressing the year 2000 computer problem. With the assistance of experts from Member States, it prepared guidance documents, aimed at operators of nuclear installations, radioactive waste management facilities and medical facilities using radiation generators or radioactive materials. Workshops were held on Y2K preparedness for nuclear power plants, waste management and medical facilities, and a workshop was held in November specifically to address contingency planning for nuclear power plants. The Agency also sent, on request, 20 missions to nuclear power plants in nine Member States to review and advise upon their Y2K preparations. The Agency's Emergency Response Centre was in operation to monitor developments in each of its Member States having nuclear power plants as local time passed through midnight from 31 December 1999 to 1 January 2000. All of the countries operating nuclear power plants confirmed to the Agency that no incident with direct safety impact had occurred at any nuclear power plant as a result of the immediate transition to the year 2000.

"An important key to strengthening safeguards is the increased use of short notice inspections within the routine inspection regime."



VERIFICATION

Importance of Additional Protocols to safeguards agreement and integrated safeguards

The Agency's safeguards system is designed to provide assurance about the exclusively peaceful use of nuclear material and facilities. It comprises extensive technical measures for independently verifying the correctness and the completeness of the declarations made by States about their nuclear material and activities. These measures relate primarily to the verification activities performed at facilities or other locations where States have declared the presence of nuclear material, equipment or relevant non-nuclear material subject to safeguards.

Since 1992 — in the aftermath of the discovery of Iraq's clandestine nuclear programme — the Board of Governors has adopted or endorsed different measures to strengthen the safeguards system (*see Box 6*). These new measures fall into two categories. The first includes measures to be implemented under the legal authority conferred by existing safeguards agreements. The second category includes measures to be implemented under the complementary legal authority conferred by Additional Protocols to safeguards agreements concluded on the basis of the Model Additional Protocol approved by the Board of Governors. When fully implemented in a State, the strengthening measures provided by a comprehensive safeguards agreement together with an Additional Protocol will allow the Agency to draw conclusions about both the non-diversion of declared nuclear material and the absence of undeclared nuclear material and activities in that State.

The combination of all safeguards measures available to the Agency under comprehensive safeguards agreements and Additional Protocols which allows these conclusions to be drawn while achieving maximum effectiveness and efficiency within available resources is referred to as integrated safeguards.

The development of the concept, plan and approach for integrated safeguards moved forward in 1999 under the direction of a group of Agency specialists. The project receives the support of a number of Member States and the technical advice of the Standing Advisory Group on Safeguards Implementation (SAGSI) and outside technical experts. The concept being developed involves a State level approach which combines integrated safeguards approaches for specific facility types with allowance for the nuclear fuel cycle in the particular State and other State specific features.

On 31 December 1999, 224 safeguards agreements were in force with 140 States (and

with Taiwan, China). Additional Protocols for 46 States had been approved by the Board of Governors. Eight such Protocols were in force and one was being implemented provisionally pending entry into force. In addition, measures contained in the Model Additional Protocol were being applied in Taiwan, China.

Throughout 1999, the Agency continued to negotiate Additional Protocols with States using the Model Additional Protocol as the standard. Progress is now needed towards achieving universal subscription to the Additional Protocol. Only then can the international community realize the full benefits of the strengthened safeguards system.

During 1999, considerable effort was devoted to the measures designed to strengthen the overall safeguards system. The Agency continued to place great emphasis on co-operating closely with State (or regional) systems for accounting and control of nuclear material so as to increase verification effectiveness and cost efficiency.

An important key to strengthening safeguards is the increased use of short notice inspections within the routine inspection regime that will give additional confidence about the declared operations of a facility. While limited frequency unannounced access is performed routinely in enrichment plants, a similar scheme of short notice random inspections

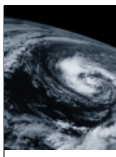
Box 6: **Measures to Strengthen Safeguards**

Under existing safeguards agreements

- Provision by States of design information on new facilities or changes in existing facilities handling safeguarded nuclear material;
- Voluntary reports by States on imports and exports of nuclear material and exports of specified equipment and non-nuclear material;
- Collection of environmental samples by the Agency in facilities and at locations where, under existing safeguards agreements, inspectors have access during inspections and design information visits;
- Use of unattended and remote monitoring of movements of declared nuclear material in facilities;
- Greater use of short notice inspections;
- Enhanced training of all relevant personnel;
- Closer co-operation between Agency and State (regional) systems for accounting and control of nuclear material;
- Enhanced collection and analysis of information derived from State declarations under safeguards agreements and from open sources.

Under the Model Additional Protocol

- Provision by States of information about, and inspector access to, all aspects of a State's nuclear fuel cycle;
- Provision by States of information on, and short notice inspector access to, any place on a nuclear site;
- Provision by States of information about and access to nuclear fuel cycle related R&D;
- Provision by States of information on the manufacture and export of sensitive nuclear related technologies, and arrangements for access to manufacturing and import locations in the State;
- Collection of environmental samples at locations beyond those provided under safeguards agreements;
- Acceptance of simplified procedures for inspector designations and issuance of multiple entry visas by the State for inspectors covering at least one year;
- Right of the Agency to make use of internationally established communications systems. ■



was developed and tested in 1999 for low enriched uranium fuel fabrication plants.

The development and use of advanced verification technology also continued in 1999. This included improved detectors, digital surveillance systems, new sealing devices and unattended verification systems. Recent technology advances have led to the introduction of remote monitoring systems. Remote monitoring may reduce the frequency of inspections, increase the capability for data review and evaluation and facilitate the remote detection and rapid response to any safeguards significant event. Its cost efficiency may vary depending on the particularities of the facility concerned and the State communications infrastructure.

Environmental sampling was being routinely applied in 1999 at facilities covered by comprehensive safeguards agreements after successful field trials in 11 Member States. The Agency's Clean Laboratory, located in Seibersdorf near Vienna, receives, handles and analyses samples and also distributes samples for analysis at laboratories belonging to the network of certified analytical laboratories. By late 1999, this network included eight laboratories in four Member States and within Euratom.

Environmental sampling has concentrated on the collection and analysis of swipe samples in enrichment plants and installations with hot cells. This is being done in order to detect any enrichment of uranium above declared levels and to confirm that hot cell facilities are not being used for undeclared activities such as plutonium production or separation. Under safeguards agreements, sampling may be extended to other types of nuclear facilities. At the end of the year, baseline samples had been collected in 12 enrichment facilities in 7 States and 77 hot cell complexes in 40 States and Taiwan, China.

For the Agency and for States that accept the provisions of the Model Additional Protocol, the preparation and handling of the related information represents a new endeavour. A computerized system known as the Protocol Data Information System was put in place in 1999 to treat all information supplied by States pursuant to their Additional Protocols, and to assist States in preparing the relevant declarations.

The confidentiality of sensitive information supplied by States is maintained under a stringent protection regime. In endorsing this regime in 1997, the Board of Governors emphasized the importance of confidentiality and the need for periodic reviews. The most recent review took place in June 1999.

To provide a comparative baseline for assessments, information on the nuclear programmes of States with comprehensive safeguards agreements in force is continuously evaluated and the findings reviewed annually. In 1999, baseline evaluations of the nuclear programmes of 18 States had been reviewed as compared with 10 in 1998 and 4 in 1997.

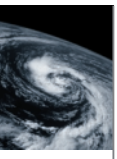
The Model Additional Protocol provides the authority and the mechanism for the Agency to exercise increased inspector access to relevant locations in a State, i.e. complementary access. By the end of the year, complementary access had taken place in Australia, Uzbekistan and Taiwan, China.

The sixth Review Conference of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) was planned to be convened for the first time under the strengthened review procedures agreed upon in 1995 when the NPT was extended on an indefinite basis. In view of developments during the past five years, the Review Conference will engage the international community in examining how the Agency's strengthened safeguards system can most effectively continue to support the goal of nuclear non-proliferation. Crucial to this goal will be continued efforts to ensure that all States party meet their obligation to conclude safeguards agreements with the Agency and that they also conclude Additional Protocols.

OUTREACH

Reaching out to non-traditional partners

One of the strategic goals reflected in the Medium Term Strategy is effective interaction



with partners and the public. Special attention was given in 1999 to reaching non-traditional partners. A particular example was the Scientific Forum organized during the General Conference, entitled 'Sustainable Development: A Role for Nuclear Power?'. The participants came from national and international scientific research centres, international organizations and non-governmental organizations, and the nuclear industry. The Forum explored how nuclear power can be compatible with sustainable development objectives, and whether the potential for global climate change will justify nuclear expansion in more competitive markets. A fundamental conclusion was that new nuclear power must be competitive in its own right without government interventions and must maintain high safety levels if it is to contribute to sustainable energy development.

Also, a meeting on 'Nuclear Research Centres (NRCs) in the 21st Century' was held in Vienna in December. The meeting brought together senior managers of NRCs from 25 Member States. A major aim was to define ways to enhance mutual co-operation among NRCs under the current challenges they face. A number of recommendations emerged from the meeting, one of them calling on the Agency to play a role in facilitating interaction between NRCs on joint projects of mutual interest and benefit in the area of nuclear technology development and applications. A second meeting is planned to focus on the details of an initially small number of projects which Member States find of most importance.

MANAGEMENT

Gaining a better understanding of the needs of Member States and ensuring a more efficient and effective response to them

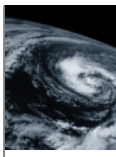
Throughout the year the Secretariat continued its management reform process. At the Senior Management Conference in January, special emphasis was given to a new approach to the programme and budget formulation process and to the efficiency of internal management. By the end of the year, a number of significant developments had taken place. Perhaps the most important was the decision that results based programming would be introduced — to the fullest extent possible — for the 2002–2003 biennium.

Meanwhile, the programme and budget for the year 2001, the initial proposals for which were prepared during the year, represented a transition. In anticipation of the introduction of results based programming, the draft programme and budget document contains *rationales*, *objectives* and *performance indicators* down to the subprogramme level. It was agreed by the Board of Governors that, as an exception, the period covered by the document would be one year only, so as to permit synchronization of the Agency biennial cycles with those of other United Nations organizations (i.e. beginning on an even numbered year).

"Perhaps the most important was the decision that results based programming would be introduced for the 2002–2003 biennium."

Proposals were put forward during the year, and approved by the Board, for the Agency — despite its statutory requirement for *annual budgeting* — to more fully utilize *biennial programming*. Thereafter, in September, the General Conference approved a change to the Statute that would allow *biennial budgeting* as a complementary measure (once the change has been ratified by the required number of States).

Programme Performance Assessment System (PPAS) evaluations were carried out in the first half of the year for Major Programmes 1, 2 and 3 (Nuclear Power and Fuel Cycle, Nuclear Sciences and Applications, and Nuclear, Radiation and Waste Safety). While it was recognized that programme priorities have to be agreed to by Member States, the PPAS evaluations provided valuable input through their recommendations to the



preparation of the programme and budget for 2001 as well as for the Medium Term Strategy (MTS).

The MTS detailed the Agency's longer term goals and the specific objectives for the five year period 2001–2005 and also specified the means proposed to meet these objectives. It aimed to show how the Agency expected to be perceived at the end of the five year time frame. The Strategy took a 'one house' approach in which all relevant activities, independent of their programmatic location, were integrated under the three broad "pillars" of technology, safety and verification. The general priorities under each goal in the MTS were indicated on the basis of the following criteria:

- Statutory responsibilities and legal commitments of the Agency;
- Decisions of the policy making organs of the Agency and the degree of priority attached by Member States to the various activities;
- Appropriateness of the Agency taking the lead vis-à-vis other institutions.

However, no attempt was made in the MTS to set detailed priorities, which would be expected to be established in future programme and budget proposals that will be developed on the basis of the Strategy and Member State comments thereon.

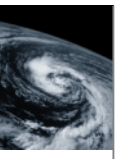
A further question that was discussed during the year was how the changing priorities for Agency programming in the nuclear applications field — under both the technical co-operation and regular programmes — might be identified. Two new methods proposed were to analyse the areas where Member State governments themselves are investing national funds, thus indicating national commitment, and to study the lending patterns of international financial institutions.

In an effort to improve synergy between programmes funded under the regular budget and technical co-operation programmes, a set of 'Management Principles for the Formulation and Implementation of the Technical Co-operation Programme' were formulated and approved. These principles, based on the concept of matrix management, provide a framework of accountability within the Agency in this area.

The other major theme for reform throughout the year was internal management practices. Following the Senior Management Conference, working groups were established to identify areas requiring streamlining and to propose appropriate changes. One of the important subjects singled out was delegation of authority for more effective management.

In recognition of the need for a change in approach, management training was taken up as a priority concern with the dual objectives of improving programme management and the effective use of resources, and creating a one house culture through Agency wide standards of good management practices. The key idea of the new management training policy was the development and implementation of a Management Certificate Curriculum, which relies almost exclusively on in-house facilitators, since the main focus is on management practices specific to the Agency. It is the first time that such a training programme has been developed in the United Nations system. By the end of the year, all the various modules of the curriculum had been pilot tested and the first full cycle organized.

A comprehensive human resources planning process was introduced to provide a closer linkage between programme requirements and human resources, and to reduce administrative work. The process will also serve as a basis for the preparation of forecasts of vacancies which will enable Member States to prospect earlier for candidates.



THE BOARD OF GOVERNORS AND THE GENERAL CONFERENCE

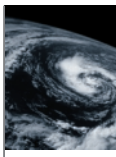
The applications of Angola and Honduras for membership of the Agency were approved by the General Conference on the recommendation of the Board of Governors. Angola subsequently deposited its instrument of acceptance of the Statute and accordingly became the 130th member of the Agency.

The Director General submitted to the Board the Agency's Medium Term Strategy (MTS), which took into account the comments of Board members on an earlier draft strategy, and which it was envisaged would form the basis for the formulation of programme proposals in the years 2001–2005 and structure of the Agency's *Annual Report* in the future. The Board took note both of the Strategy and of the comments made on the understanding that, being a rolling text, it could be used as a starting point and a reference document in the formulation of programme proposals.

The General Conference achieved a successful resolution to the long running question of the amendment of Article VI of the Statute. By resolution GC(43)/RES/19, having considered the Board's observations, the General Conference approved an amendment proposed by Japan, as modified by Slovenia and subsequently further modified, concerning the size and distribution of seats on the Board, by which membership of the Board was expanded from 35 to 43 seats. The amendment further provided that this provision would enter into force only when the Board adopted, and the General Conference confirmed, a list of all Member States of the Agency, whereby each Member State was allocated to one of the areas referred to in the amended Article VI. The General Conference urged all Member States of the Agency to accept the amendment as soon as possible, in accordance with their respective constitutional processes.

The General Conference, having considered the observations of the Board of Governors, approved an amendment to Article XIV.A of the Agency's Statute submitted by Slovenia, so as to provide for biennial budgeting in the Agency. This was preceded earlier in the year by the Board's endorsement of the Secretariat's proposals with respect to biennial programming changes. Both this amendment and the amendment to Article VI have since been circulated to Member States for ratification as required by the Statute.

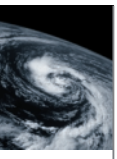
The Board considered the issue of the proliferation potential of neptunium and americium on a number of occasions during the year. With regard to neptunium, while the Board acknowledged that the proliferation risk was



considerably lower than for uranium or plutonium, it authorized the Director General to apply the monitoring scheme which he had recommended, and further recognized that monitoring should be carried out on a voluntary basis. With regard to americium, while there was at present practically no proliferation risk, the Board decided that the Director General should report to it, when appropriate, with regard to the availability of

Resolutions of the General Conference in 1999

Number	Title	Date adopted (1999)
GC(43)/RES/1	Application by Honduras for membership of the Agency	27 September
GC(43)/RES/2	Application by Angola for membership of the Agency	27 September
GC(43)/RES/3	Implementation of the agreement between the Agency and the Democratic People's Republic of Korea for the application of safeguards in connection with the Treaty on the Non-proliferation of Nuclear Weapons	1 October
GC(43)/RES/4	The Agency's Accounts for 1998	1 October
GC(43)/RES/5	Regular Budget appropriations for 2000	1 October
GC(43)/RES/6	Technical Co-operation Fund Allocation for 2000	1 October
GC(43)/RES/7	The Working Capital Fund in 2000	1 October
GC(43)/RES/8	Amendment of Article XIV.A of the Statute	1 October
GC(43)/RES/9	Scale of assessment of members' contributions for 2000	1 October
GC(43)/RES/10	The safety of radiation sources and the security of radioactive materials	1 October
GC(43)/RES/11	Safety of transport of radioactive materials	1 October
GC(43)/RES/12	The radiological protection of patients	1 October
GC(43)/RES/13	Measures to strengthen international co-operation in nuclear, radiation and waste safety	1 October
GC(43)/RES/14	Strengthening of the Agency's technical co-operation activities	1 October
GC(43)/RES/15	Plan for producing potable water economically	1 October
GC(43)/RES/16	Extensive use of isotope hydrology for water resources management	1 October
GC(43)/RES/17	Strengthening the effectiveness and improving the efficiency of the safeguards system and application of the Model Protocol	1 October
GC(43)/RES/18	Measures against illicit trafficking in nuclear materials and other radioactive sources	1 October
GC(43)/RES/19	Amendment to Article VI of the Statute	1 October
GC(43)/RES/20	Personnel: Staffing of the Agency's Secretariat	1 October
GC(43)/RES/21	Personnel: Women in the Secretariat	1 October
GC(43)/RES/22	Implementation of United Nations Security Council resolutions relating to Iraq	1 October
GC(43)/RES/23	Application of IAEA safeguards in the Middle East	1 October
GC(43)/RES/24	Examination of delegates' credentials	1 October



this material and relevant emerging programmes in States. The Board called on all States to protect and control these materials.

With regard to the financing of technical co-operation, at the request of the General Conference the Board began discussions with a view to recommending to the General Conference target figures for 2001–2002 and Indicative Planning Figures for 2003–2004. The Ambassadors of Finland and Mexico were appointed by the Board as joint co-ordinators to engage in consultations with interested Member States.

As the General Conference had requested in 1995 that the Board review arrangements for the financing of the safeguards component of the Regular Budget by 2000 at the latest, the Board agreed to initiate consultations among interested Member States with a view to the approval of arrangements in June 2000. Accordingly, the Ambassador of Spain was appointed to undertake the consultations.

The General Conference appointed the Comptroller and Auditor General of the United Kingdom as the External Auditor to audit the Agency's accounts for the years 2000 and 2001.

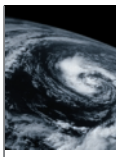
The Board approved the adoption of an Agency flag and its use in accordance with a flag code, which was subsequently promulgated by the Director General.

The Board of Governors, 1999–2000

The composition of the Board of Governors in 1999–2000 at the conclusion of the 43rd (1999) regular session of the General Conference was as follows:

- Algeria
- Argentina
- Australia
- Austria
- Belarus
- Bolivia
- Brazil
- Canada
- Chile
- China
- Cuba
- Egypt
- Finland
- France
- Germany
- Greece
- India
- Indonesia
- Japan
- Jordan
- Republic of Korea
- Nigeria
- Norway
- Poland
- Russian Federation
- Saudi Arabia
- Singapore
- Slovakia
- South Africa
- Sudan
- Sweden
- Syrian Arab Republic
- United Kingdom of Great Britain and Northern Ireland
- USA
- Uruguay

The Chairman of the Board for 1999–2000 was H.E. Sergio de Queiroz Duarte of Brazil. The Vice-Chairmen were H.E. Tom Grönberg of Finland and H.E. Miroslav Lipár of Slovakia. ■



General Conference Resolution GC(43)/RES/19
AMENDMENT TO ARTICLE VI OF THE STATUTE

Resolution adopted on 1 October 1999 during the ninth plenary meeting

The General Conference,

(a) *Recalling* its decision GC(42)/DEC/10 which requested the Board of Governors, inter alia, to submit its report on a finalized formula on amending Article VI of the Statute and all previous resolutions and decisions on the subject,

(b) *Having examined* the proposal for amendment of Article VI of the Statute submitted by Japan in accordance with Article XVIII.A of the Statute, contained in Annex 1 to document GC(42)/19,

(c) *Having also examined* the proposal for the modification of the Japanese amendment submitted by Slovenia in accordance with Article XVIII.A of the Statute, contained in document GC(43)/12,

(d) *Having also considered the report and recommendations* of the Board of Governors contained in document GC(43)/12, which constitute the Board's observations on the aforesaid modification to the Japanese proposal proposed by Slovenia,

(e) *Having also considered* the Board's observations on the aforesaid Japanese proposal to amend Article VI,

1. *Approves* the aforesaid modification proposed by Slovenia to the amendment of Article VI proposed by Japan;

2. *Approves* the amendment proposed by Japan, as modified in operative paragraph (1) and as further modified, by which Article VI of the Agency's Statute is amended as follows:

I. Replace paragraph A of Article VI of the Agency's Statute by the following:

"A. The Board of Governors shall be composed as follows:

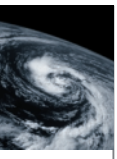
1. The outgoing Board of Governors shall designate for membership on the Board the eighteen members most advanced in the technology of atomic energy including the production of source materials, the designated seats to be distributed among the areas mentioned below as follows:

North America	2
Latin America	2
Western Europe	4
Eastern Europe	2
Africa	2
Middle East and South Asia	2
South East Asia and the Pacific	1
Far East	3

2. The General Conference shall elect to membership of the Board of Governors:

(a) Twenty-two members, with due regard to equitable representation on the Board as a whole of the members in the areas listed in sub-paragraph A.1 of this article, so that the Board shall at all times include in this category:

four representatives of the area of Latin America,
four representatives of the area of Western Europe,
three representatives of the area of Eastern Europe,
five representatives of the area of Africa,
three representatives of the area of the Middle East and South Asia,
two representatives of the area of South East Asia and the Pacific, and
one representative of the area of Far East.



AMENDMENT TO ARTICLE VI OF THE STATUTE (cont.)

(b) Two further members from among the members in the following areas:

Western Europe
Eastern Europe
Middle East and South Asia

(c) One further member from among the members in the following areas:

Latin America
Eastern Europe"

and

II. Add at the end of Article VI the following new paragraph:

"K. The provisions of paragraph A of this Article, as approved by the General Conference on 1 October 1999, shall enter into force when the requirements of Article XVIII.C are met and the General Conference confirms a list of all Member States of the Agency which has been adopted by the Board, in both cases by ninety per cent of those present and voting, whereby each Member State is allocated to one of the areas referred to in sub-paragraph 1 of paragraph A of this Article. Any change to the list thereafter may be made by the Board with the confirmation of the General Conference, in both cases by ninety per cent of those present and voting and only after a consensus on the proposed change is reached within any area affected by the change".

3. *Urges* all Member States of the Agency to accept this amendment as soon as possible in accordance with their respective constitutional processes, as provided for in Article XVIII.C(ii) of the Statute;

4. *Requests* the Director General to report to the General Conference, at its 45th regular session on the progress made towards the entry into force of this amendment. ■

General Conference Resolution GC(43)/RES/8
AMENDMENT OF ARTICLE XIV.A OF THE STATUTE

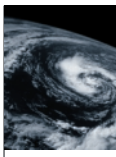
Resolution adopted on 1 October 1999 during the ninth plenary meeting

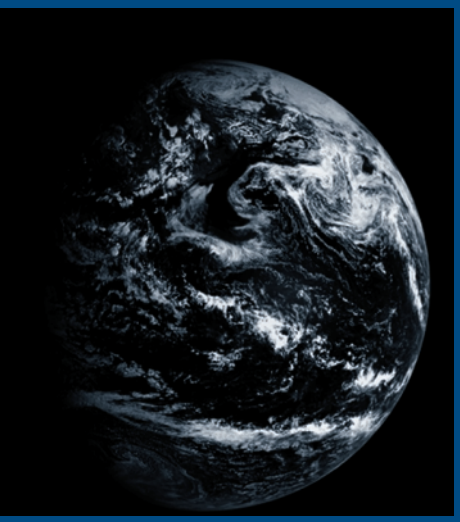
The General Conference,

Having considered the proposal for amendment of Article XIV.A of the Agency's Statute submitted by Slovenia as contained in Annex 2 to document GC(43)/24 in accordance with Article XVIII.A of the Statute,

Having also considered the report and recommendation of the Board of Governors on the proposal for amendment contained in document GC(43)/24, which constitutes the Board's observations on the amendment submitted in accordance with Article XVIII.C(i) of the Statute,

Approves the aforesaid amendment to replace the word "annual" with the word "biennial" in the first sentence of Article XIV.A of the Statute. ■



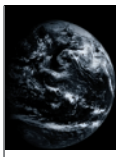


The Agency's Programme in 1999: Technology

NUCLEAR POWER

PROGRAMME OBJECTIVE

To assist Member States, at their request, in planning and implementing programmes for the utilization of nuclear power, as well as to support them in achieving improved safety, reliability and economic cost effectiveness of their nuclear power plants by promoting advanced engineering and technology, training, quality assurance and infrastructure modification.



OVERVIEW

Internal and external reviews led to a reformulation of the programme in 1999. There was greater emphasis on the planning of nuclear power programmes using small and medium size reactors in developing countries. Work on the erosion/corrosion of plant components, and on the effects of energy market deregulation on nuclear power plant operation and performance improvement was rationalized in order to make more efficient use of resources. And there was a new focus in the training of power plant personnel on the need to maintain important capabilities and skills in the light of an ageing workforce. In the field of technology development, there was increased emphasis on status reviews and the dissemination of information. Elements of a strategic plan for an international R&D project on innovative nuclear fuel cycles and power plants were developed. Sharing and preservation of technical data received increased attention, and educational workshops and training in specific aspects of nuclear power development and applications were carried out.

NUCLEAR POWER PLANNING, IMPLEMENTATION AND PERFORMANCE

Work in this area seeks to facilitate the exchange of experience and provide assistance to Member States in nuclear power programme planning and in economic analyses, including cost–benefit analysis of upgrades to nuclear

plants and plant life extension. In particular, assistance was provided to Bangladesh, Egypt, Morocco, Turkey and Viet Nam in the areas of nuclear power planning, feasibility studies and infrastructure development.

A database for the Nuclear Economic Performance Information System (NEPIS) was developed. NEPIS contains information on several aspects of economic performance, including operation and maintenance (O&M) costs, safety, and economic and operational indicators. The first pilot project to collect and validate an initial set of data was completed in June. Related to this, a technical document was prepared on the development of a nuclear economic performance information system to enhance nuclear power plant competitiveness. This document addresses transformations in electricity markets and the business environment, and provides guidance to utilities on optimizing economic and technical performance.

"The Agency's Power Reactor Information System (PRIS) seeks to promote improvements in the operating performance of nuclear power plants."

A new CRP was initiated on national approaches to correlate performance targets and O&M costs. The focus is on optimizing these costs, identifying high and low cost areas in O&M activities, establishing the financial impact of extended outages and identifying refuelling costs. The relevance of this CRP is that if analyses at a national level of historical cost data can be translated into an international database, it can facilitate the communication of trends and best practices in the industry and help build up a set of international economic indicators.

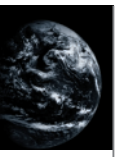
The Agency's Power Reactor Information System (PRIS) seeks to promote improvements in the operating performance of nuclear power plants through the collection, assessment and dissemination of: utility experience and practices; information on the operating performance of nuclear power plants; and analyses of subject areas affecting performance. To facilitate this process, a CD-ROM version of PRIS was developed. Currently, the Agency's two PRIS services, MicroPRIS and PRIS-PC (the connection to PRIS through the Internet), are distributed to more than 600 users in Member States and international organizations.

In addition, implementation of a 'virtual office' has begun for PRIS. Virtual office is an Internet forum to exchange information and improve the efficiency of Agency interaction with its Member States. One of its major advantages is the capability to maintain an integrated and up-to-date view of project information.

A new data module, the International Database on Piping of Nuclear Power Plants, was completed. This module includes information on piping material properties, non-destructive examination of pipelines and piping failures. With the software having been prepared, first data input from Member States is expected to be provided by the end of 2000.

In the area of nuclear power plant life management, a CRP on assuring the structural integrity of reactor pressure vessels (RPVs) was completed. A number of recommendations for further activities were proposed. For example, the 18 Member States participating in the CRP recommended the use of Agency reference steel as the basis of comparison for future international studies on RPV materials. In addition, further research was recommended on the application of surveillance programme results to RPV integrity assessments and on the mechanism of the nickel effect in the radiation embrittlement of RPV steels.

A key area in nuclear power plant performance is instrumentation and control. In order to provide guidance and information, a database was developed on operator support systems (OSSDB) containing the most pertinent characteristics of such systems. The database focuses on users, their needs and the benefits of using OSS.



The aim of the Agency's 'Strategy for Technical Co-operation' is to promote socioeconomic development by contributing in a cost effective manner to activities that address key welfare priorities. As part of this strategy, technical support was provided in such areas as the implementation of first or new nuclear power projects, and national nuclear infrastructure development, including personnel training, infrastructure, plant life management and improved operations management. Most of these technical co-operation efforts were concentrated in the Europe and Asia–Pacific regions.

NUCLEAR POWER REACTOR TECHNOLOGY DEVELOPMENTS

The International Working Group on Advanced Technologies for LWRs met in Vienna in May and advised that priority continue to be given to information exchange on technology advances for improving the economics of current and future LWRs. Greater emphasis was also recommended on technologies for achieving a high level of safety, and on the sharing and preservation of technical data. In addition, the involvement of young engineers in nuclear power technology development was seen as priority.

A CRP on the establishment of a thermophysical properties database for LWR and HWR materials was initiated. The objective is to foster the exchange of non-proprietary information on the thermophysical properties of these materials to achieve improvements in design and safety. A peer reviewed database of properties under normal, transient and severe accident conditions will be established on the Internet. Efforts are also under way to critically assess available thermophysical property data and make recommendations for experiments where data are currently lacking, or uncertainties need to be reduced. The LWR and HWR materials that will be studied include fuels, cladding, pressure tube and calandria materials, absorbers, structural materials, and the behaviour of liquids and mixtures under severe accident conditions.

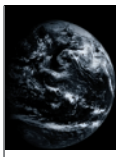
The use of efficient technologies for improving nuclear power plant O&M is an important element in ensuring their economic competitiveness with other means of generating electricity. Furthermore, as currently operating plants age, proper management requires the development and application of better technologies for inspection, maintenance and repair. In designing future plants, various features that facilitate efficient inspection, maintenance and repairs can be incorporated at the outset.

The technologies for improving current and future LWR operation and maintenance were investigated at a Technical Committee meeting hosted by the Nuclear Power Engineering Corporation at the Kashiwazaki-Kariwa Nuclear Power Station from 24 to 26 November. Convened within the framework of the Agency's International Working Group on Advanced Technologies for Light Water Reactors, the topics that were addressed included:

- Programmes for extending plant lifetime and or improving performance and reliability;
- Equipment and techniques for component inspection, maintenance, repair and replacement;
- Methods for reducing fuelling cost and refuelling outage duration;
- Advances in design to achieve improved operation and maintenance.

The third meeting of the International Working Group on Advanced Technologies for Heavy Water Reactors was held in Vienna in June. One of the recommendations was that work in this area have two tracks: activities directed towards a long term strategic vision, and technical activities. It was also recommended that greater attention be devoted to safety aspects of HWR technology development.

Small reactors are those that have electrical power (or equivalent thermal power) of less than 300 MW(e), while medium reactors have electrical power between 300 and 700 MW(e). Such small and medium reactors (SMRs) are a suitable option for electricity generation in countries with small electricity grid capacities, or in remote areas. They can also be used for non-electrical and cogeneration applications,



including the desalination of seawater and district heating, as well as for the production of high temperature process heat. Work on SMRs in 1999 included the convening of an Advisory Group meeting in October in Vienna on the development of a strategic plan for an international R&D project on innovative nuclear fuel cycles and power plants. The outcome of this meeting was a set of recommendations for Agency support in this area and the identification of nine candidate projects. Operating experience from small size reactors used for the propulsion of icebreakers and freight carriers was reviewed at an Advisory Group meeting and by consultants. There was agreement that with some design modifications, these reactors could be used either for electricity supply or for non-electrical applications such as district heating and desalination, particularly in remote areas. The results of the various meetings are being consolidated and will be presented in a technical document.

"A study on the economics of nuclear desalination highlighted the conditions under which nuclear desalination would be competitive with fossil alternatives."

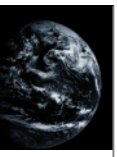
Gas cooled reactors (GCRs) are capable of high temperature operation, offering increased efficiency in the production of electricity and the potential for high temperature process heat applications. Increasing international interest in GCRs is evident from construction and startup activities at two high temperature gas cooled research reactor facilities in Japan and China, as well as two international reactor design projects.

The International Working Group on Gas Cooled Reactors met in the United Kingdom in September to review activities in the field and provide recommendations for future efforts. The group noted that the gas turbine high temperature reactor (HTR) designs currently under development are well suited for nuclear desalination in a cogeneration mode and recommended that they be included in Agency nuclear desalination activities. The IWG also recommended that future GCR meetings be directed toward the establishment of modular HTR safety and licensing criteria and related safety analysis and equipment classification.

The final Research Co-ordination meeting for a CRP on the design and evaluation of heat utilization systems for the High Temperature Engineering Test Reactor (HTTR) was held in October in Japan. The focus of this meeting was on heat utilization systems, including steam reforming of methane for the production of hydrogen and methanol, use of a gas turbine for electricity generation, carbon dioxide reforming of methane for the production of methane or syn-gas, hydrogen production by thermochemical water splitting, and coal conversion and enhanced oil recovery. A technical document on the results of this CRP is currently being prepared.

A Technical Committee meeting on the prospects of non-electrical applications of nuclear energy was held in Beijing. The meeting reviewed information on the prospect, design, safety and licensing aspects, and development of non-electrical applications of nuclear heat for industrial use. This included seawater desalination and hydrogen production.

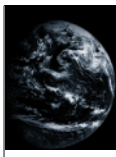
The International Nuclear Desalination Advisory Group (INDAG), at its third meeting in June, reviewed national programmes and projects in Member States and stressed the importance of facilitating international co-operation in nuclear desalination demonstration activities. The outcome of the first meeting of an interregional technical co-operation project on integrated nuclear and desalination system design, held in May in the Republic of Korea, was also reviewed. In addition, recommendations on further analyses of country needs and follow-up actions by the Agency were made. Related work in this area included a comprehensive study co-ordinated by the Agency on the overall economics of nuclear desalination as compared with the use of fossil energy. The study highlighted the conditions under which nuclear desalination would be



competitive with fossil alternatives. The conditions were identified using as examples three typical regions, a wide range of nuclear and fossil power options and two economic scenarios. Some of the parameters included seawater salinity and temperature, water plant capacity, construction cost and the interest rate applied.

The Agency's activities in the area of liquid metal cooled reactors and emerging nuclear energy systems for energy generation and the transmutation of actinides included the initiation of a CRP on updated codes and methods to reduce the calculational uncertainties of liquid metal fast reactor reactivity effects. The objective is to verify, validate and improve methodologies and computer codes for the calculation of reactivity coefficients in plutonium and minor actinide burning reactors through the intercomparison of methods, nuclear data and codes, and experimental results developed and used by different institutes. This activity is of particular relevance in view of the eventual utilization of weapons grade plutonium in fast reactors.

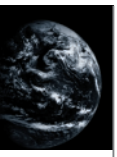
A comprehensive review at an Advisory Group meeting of national R&D programmes on accelerator driven systems (ADS) was carried out. The purpose was to review the status of such programmes and assess progress in the development of hybrid concepts, as well as their potential role relative to both the current status and the future direction of nuclear power worldwide. At the same time, the review provided options and guidance for Agency activities in the area of ADS.



NUCLEAR FUEL CYCLE AND WASTE TECHNOLOGY

PROGRAMME OBJECTIVE

To facilitate the transfer and exchange of information and technology among Member States; to provide assistance and guidance, when requested, on the formulation and implementation of strategies in nuclear fuel cycle related activities and radioactive waste management programmes with due regard to efficiency, safety, environmental soundness and sustainability, and consistency with internationally accepted norms, where applicable, and good practices.



OVERVIEW

The Agency's activities in the nuclear fuel cycle area focused on: uranium supply and demand and the environmental issues related to uranium mining and milling; immediate challenges in reactor materials and fuel technology, such as those associated with increased burnup; spent fuel management; and nuclear fuel cycle issues and databases. A symposium on MOX fuel cycle technologies for medium and long term deployment was held in Vienna in May.

The radioactive waste technology programme covered: sources of radioactive waste (with emphasis on inventories, minimization and decommissioning of facilities); implementation of waste management activities (with a greater focus on disposal issues); and technology transfer and exchange. The experience gained in implementing technologies to manage radioactive waste from nuclear power plants and the back end of the nuclear fuel cycle was reviewed at a symposium in Taejon, Republic of Korea. The progress of work, including the status of national radioactive waste management programmes, was discussed at the fourth meeting in September of the Radioactive Waste Technology Advisory Committee.

NUCLEAR FUEL CYCLE AND MATERIALS

A report addressing the impact on the environment and mitigation of any adverse environmental effects from uranium mining and milling operations was prepared jointly by the Agency and the OECD/NEA. This is the first report on the subject and underlines the importance of good environmental practices if uranium is to be a sustainable fuel source in the 21st century. The report includes a profile of environmental activities and issues related to uranium production, based on responses from 29 countries to a survey.

At a symposium on MOX fuel cycle technologies for medium and long term deployment, organized in co-operation with the OECD/NEA and held in Vienna in May, issues such as the design, technology, utilization, performance, safety, safeguards, transportation and management of separated civil and weapons origin plutonium and potential advanced cycle options were discussed. There was agreement that with more than 2000 MOX assemblies fabricated from 85 tonnes of plutonium and loaded into power reactors, the recycle process was at a mature stage. The technology is well understood, the facilities, institutions and procedures are in place, and capacities are available or are being made available to meet the anticipated increase in the quantities of separated civil plutonium from the production of nuclear power. It was noted that the number of countries engaged in plutonium recycle is expected to increase in the near future, the aim being to reduce stockpiles of separated plutonium from existing reprocessing contracts. While projections of the extended use of MOX fuel in the future depend on the commercial introduction of advanced reactor systems, such as fast power reactors, there was consensus that this would be the optimal method to close the nuclear fuel cycle and to utilize separated plutonium, as well as to burn long lived radioactive actinides accumulated in spent fuel.

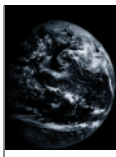
Support to technical co-operation activities included the holding of a workshop for users of the TRANSURANUS code, in Pamporovo, Bulgaria, following the Third International Seminar on WWER Fuel Performance, Modelling and Experimental Support. This code, developed by the European Commission's Institute for Transuranium Elements, was modified in order to model the behaviour of WWER fuel. These modifications were then validated by the joint OECD/NEA–IAEA–IFPTE Database. This code will help Member States license this fuel using data on fuel behaviour under different conditions.

The increasing importance of the long term storage of spent fuel was illustrated at a Technical Committee meeting in Vienna in November on good practices for the long term storage of spent fuel, including advanced, high burnup and MOX fuel. Issues associated with materials behaviour, reliability and the safety of different storage technologies for long periods of time were major items of discussion. In addition, the activities of a number of Member States who have embarked on detailed fuel performance programmes for dry storage technologies were reviewed.

"There was agreement that extended use of MOX fuel would be the optimal method to close the nuclear fuel cycle and to utilize separated plutonium."

A Technical Committee meeting/workshop on spent fuel management for WWER/RBMK reactors was held in October. Hosted by PURAM and the Paks nuclear power plant at Balatonfüred, Hungary, the workshop was part of the Extrabudgetary Programme on the Safety of WWER and RBMK Nuclear Power Plants and was supported by the Government of Japan. Information on operation, monitoring and maintenance of spent fuel storage facilities, fuel degradation mechanisms, damaged/failed fuel, and economic considerations was exchanged.

At a symposium on research reactor utilization, safety and management, held in Lisbon,



Portugal, in September, the focus was on: the management of spent fuel and of waste from operation and utilization; refurbishment, decommissioning and dismantling of facilities; the transfer of aluminium clad research reactor fuel from wet to dry storage; repatriation of spent fuel to the country where it was originally enriched; and the implementation of regional or international facilities for the interim storage and eventual disposal of spent fuel. Urgent issues in the area of spent fuel management that were identified at the symposium included: the need for realistic spent fuel management plans at each facility; the preparation and continuation of the repatriation of spent fuel to its country of origin; and the need for regional solutions for countries with research reactors but no power reactor programme.

An interregional course organized by the Agency and the USA at Argonne National Laboratory in May examined the technical and administrative preparations required for shipping spent fuel from research reactors, particularly in developing Member States, back to the fuel's country of origin. The course also covered the preparations for the repatriation of Russian origin spent research reactor fuel in the expectation that a take-back programme by the Russian Federation would be implemented in the near future.

It was announced at the General Conference session in September that the US Government was prepared to work with the Russian Federation and the Agency to manage and dispose of Russian origin research reactor fuel and to support a tripartite meeting on the issue. At this meeting, which was held in December, the status worldwide of Russian origin research reactor fuel, and priority areas requiring more study were reviewed.

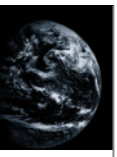
Issues associated with the nuclear fuel cycle, especially those related to the back end, were major topics of discussion at the second meeting in June of the International Working Group on Nuclear Fuel Cycle Options. Many of the back end fuel cycle issues identified at this meeting were topics of further discussion at a Technical Committee meeting in November on the factors determining the long term back end nuclear fuel cycle strategy and future nuclear systems. The meeting concluded that regardless of the fuel cycle options (once-through or reprocessing/recycling), it was important to demonstrate that the back end of the nuclear fuel cycle could be completed.

The objective of an Advisory Group meeting in October was to formulate a strategic plan for international R&D projects on innovative nuclear fuel cycles and power plants. A major recommendation was that the role of the Agency in the implementation of innovative fuel cycles and reactor designs should be defined so as to facilitate co-ordination of R&D on: safeguards friendly technologies; high level waste reduction; non-aqueous reprocessing; natural circulation phenomena; and accelerator driven systems.

SOURCES OF RADIOACTIVE WASTE

Radioactive waste results from the generation of electricity using nuclear energy and from nuclear applications in medicine, research and industry. One of the fundamental principles of radioactive waste management is minimization, which includes both the reduction of waste being generated and of the volumes of waste already generated. Waste minimization has benefits through the more efficient use of resources and through reduced waste processing and disposal costs. A technical document, *Minimization of Waste from Uranium Purification, Enrichment and Fuel Fabrication*, was published that reviews existing practices and experience gained in the minimization of operational and decommissioning waste from the front end of the nuclear fuel cycle. This information can help Member States when making investment decisions and planning facility improvements.

An important element of waste minimization is the recycle and reuse of valuable materials from different arisings at nuclear fuel cycle facilities (such as byproducts, spent and unused process materials, plant components and equipment), which would otherwise be



considered waste. The economic advantages, coupled with the reduced environmental impact, are strong incentives to choose the recycle and reuse option. Recognizing the importance of this subject and the interest of Member States, a technical document was prepared that analyses different recycle and reuse options in relation to various areas of the nuclear fuel cycle and different nuclear applications. This will allow the recycle and reuse option to be properly implemented as a part of national, site and plant specific waste management policies.

The subject of waste minimization during decommissioning has assumed great importance because of the large number of facilities that have to be retired from service in the near future in many Member States. A technical report on this issue was prepared that discusses various stages and components in the decision making and implementation of waste minimization programmes during decommissioning operations.

A technical report on the estimation of wastes arising from various nuclear fuel cycles was completed. The literature describing these arisings is mostly oriented towards the individual steps of the nuclear fuel cycle, while more detailed information summarizing and assessing the potential impact of waste generation from the entire fuel cycle is virtually non-existent. This report was thus aimed at providing information (i.e. of quantities and basic characteristics) on waste generation in various nuclear fuel cycles and the subsequent steps in its management.

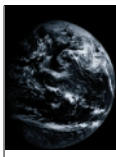
On-site disposal (i.e. the permanent disposal of a nuclear facility or parts thereof within the site where the facility was erected and operated) was proposed some years ago and implemented in a few cases. A technical document was published to present the experience gained, and the prospects for national approaches to on-site disposal. This document should also meet the needs of developing countries that have research reactors and other small nuclear installations.

Environmental restoration is an important source of radioactive waste as sites which do not meet current standards for release are cleaned up. A CRP on site characterization techniques used in environmental restoration was completed, with the final Research Co-ordination meeting being held in Brazil. The technical document resulting from this project gives a comprehensive overview of the various on-site, in situ and laboratory techniques used to deal with contamination problems from various origins. The importance of proper and thorough site characterization, and the need for reverification as work proceeds as a basis for efficient cleanup were also stressed in this document.

"A symposium held in Taejon documented that proven technologies do exist for managing radioactive wastes in ways that are safe, economical and environmentally sound."

IMPLEMENTATION AND APPLICATION OF RADIOACTIVE WASTE MANAGEMENT TECHNOLOGIES

An important method to help evaluate performance and engender confidence in the safety of geological disposal systems is to carry out analogue studies. A technical report was issued that presents the current status of natural analogue information in evaluating models of transport by groundwater for those planning to develop a research programme in this field. Similarly, to help evaluate and provide confidence in the models and data used in the assessment of the long term behaviour of geological disposal systems, a new CRP on anthropogenic analogues will allow comparison of the behaviour of various components of a repository system with the behaviour of similar systems that either occur or have occurred on Earth. Migration processes related to ancient artefacts and building materials used in archaeological times are the main topics of study in this CRP.



WASTE MANAGEMENT INFORMATION AND TECHNOLOGY TRANSFER

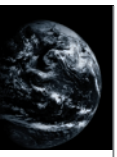
A symposium was held in Taejon, Republic of Korea, to review experience gained worldwide in implementing technologies to manage radioactive waste from nuclear power plants and the back end of the nuclear fuel cycle. Organized in co-operation with the OECD/NEA, the Korea Atomic Energy Research Institute, the International Union of Producers and Distributors of Electrical Energy, and the Nuclear Energy Institute, the symposium documented that proven technologies do exist for managing radioactive wastes in ways that are safe, economical and environmentally sound, and that considerable experience exists with these technologies in many Member States. Over the life of the commercial nuclear industry, technologies for managing operational wastes from nuclear power plants have improved substantially and continue to improve in response to economic and environmental considerations. More attention to waste minimization and volume reduction technologies has led to substantial reductions in the volumes of solid wastes. Improvements continue to be made in the technologies and methods that are used to investigate and select sites for waste disposal, and in the construction and operation of the disposal facilities themselves.

A number of activities were undertaken to support developing Member States build up their capacity to safely manage radioactive wastes. For example, regional demonstrations of pre-disposal waste management methods and procedures were held in operating waste processing and storage facilities in Chile, Philippines, the Russian Federation and Turkey. The demonstrations provided hands-on experience in the processing and storage of, for example, low level solid and liquid waste.

Member States were also assisted in the safe management of spent sealed radiation sources, particularly unused radium sources. For example, spent radium sources were conditioned and transferred into long term storage in China, Costa Rica, Jamaica, Pakistan, Peru and the United Republic of Tanzania with the assistance of expert teams from Brazil (for Latin America), South Africa (for Africa) and national expert teams in China and Pakistan. In addition, the team from Pakistan will assist in conditioning spent radium sources in other Member States in Asia.

The Contact Expert Group (CEG) for International Co-operation in Radioactive Waste Management with the Russian Federation agreed at its meeting in Norway to approach the leaders of the G-7/G-8 countries directly with information on nuclear waste and spent fuel issues in the Russian Federation, and appeal for assistance in solving these problems. The final text of the CEG's communication was forwarded thereafter to the Chairman of the G-7/G-8 Nuclear Safety Working Group and by several CEG members to their national representatives.

In May, the Hungarian Atomic Energy Authority requested the Agency to organize an international peer review of the research on site selection and suitability of the Üveghuta candidate site for low and intermediate level waste disposal, within the framework of the Agency's Waste Management Assessment and Technical Review Programme. Specifically, an evaluation was requested of: (a) the screening process, including the associated regulatory framework, that led to the selection of this site; (b) the scientific investigations that were conducted to determine if they were carried out in accordance with international requirements and guidance; and (c) whether good scientific and engineering practices were used. The Agency team conducted the review in November and concluded that the process leading to the selection of the site appeared both reasonable and appropriate and took into account both the geology and the question of public acceptance. The team also concluded that the Üveghuta site appeared potentially suitable for a safe repository for low and intermediate level operational and decommissioning wastes from nuclear power plants.



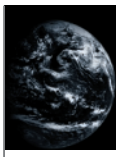
COMPARATIVE ASSESSMENT OF ENERGY SOURCES

PROGRAMME OBJECTIVE

To facilitate national and international assessments of nuclear power in the context of full source-to-service energy chains, with the aim of supporting sustainable energy development in increasingly competitive electricity markets. To explore the role of nuclear power for sustainable energy system development and to assist Member States in making informed policy decisions about their future energy development.

OVERVIEW

The programme on comparative assessment of energy sources developed methodological tools for informed policy and decision making for use in Member States. This included the development of tools for comprehensive comparative assessment of all energy supply options, and economic analysis of issues related to the nuclear fuel cycle and to the supply and use of nuclear power in changing electricity markets. These studies aim to identify: the potential role for nuclear power in achieving sustainable energy development; the relative economics of different electricity generating options; other potential barriers to the future use of nuclear power; and the environmental costs and benefits of nuclear and other options. Capacity building in Member States in these areas was pursued through the dissemination of methodologies and through training. The programme was also restructured in order to: (a) launch a new activity focusing on the role of nuclear power as a greenhouse gas (GHG) mitigation option, especially under the flexible mechanisms of the Kyoto Protocol; and (b) participate proactively in United Nations system-wide activities related to sustainable development.



ENERGY DEMAND ANALYSIS, SUPPLY OPTIONS AND INDICATORS FOR SUSTAINABLE ENERGY DEVELOPMENT

Despite the need for sustainable development, and the fact that energy is a key input for all socioeconomic development activities, indicators for sustainable energy development (ISED) have not been developed anywhere. The need for such indicators has become even more acute since current work in this area has focused on *general* sustainable development indicators. In response, the Agency initiated a project, with the help of Member States and other international organizations, to define a comprehensive set of indicators that measure and monitor the development of the energy sector in conformity with the objectives of sustainable development. The availability of ISED would help in: (a) evaluating the role of energy in sustainable development strategies; (b) making necessary modifications to the Agency's databases and analytical tools so as to make them more responsive to sustainable energy development issues; and (c) rendering assistance to Member States in the formulation of their energy strategies in conformity with the objectives of sustainable development. Following further refinement, these indicators will be submitted to the United Nations Commission on Sustainable Development for consideration during its ninth session (UNCSD-9), to be held in April 2001. This meeting will, for the first time, hold discussions on energy in relation to sustainable development.

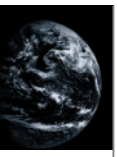
"An example of the Agency's pursuit of synergy with other international organizations was a study with the OECD/NEA on long term projections of energy and electricity demand and supply to 2100."

Since sustainable development necessarily has a strong economic component, assessing the economics of nuclear power is essential. A number of studies were completed, some with other organizations, exploring the competitiveness and the economic future of nuclear power in general, as well as the economics of specific aspects of the nuclear power cycle. One such study culminated in the publication of a technical document entitled *Strategies for Competitive Nuclear Power Plants* (IAEA-TECDOC-1123). A number of other studies were also initiated, including one on liability management in the decommissioning and waste disposal phases of the nuclear cycle, and another on the need for cost effective safety approaches in nuclear power plants. In related work, a CRP on the impact of infrastructure requirements on the competitiveness of nuclear power was initiated. The first Research Co-ordination meeting was convened in December.

An example of the Agency's pursuit of synergy with other international organizations was the completion of a study with the OECD/NEA on long term projections of energy and electricity demand and supply to the year 2100, and adapting them to explore the impact of competitive markets on the future market share of nuclear power, the consequences of any decision to phase out nuclear power on emissions affecting air quality, regional acidification and climate change as well as nuclear power's potential role in mitigating GHG emissions over the very long run.

NUCLEAR ENERGY IN SUSTAINABLE ENERGY STRATEGIES

The Agency has for many years provided data, information and analytical tools for making informed decisions on how best to meet the energy needs of a country. These tools have been distributed in over one hundred countries and to 12 international organizations. In 1999, model development efforts focused on creating improved versions of the Agency's most widely used energy planning tools, including DECPAC, MAED, WASP and ENPEP, which are used for the comparative assessment of energy options, analysis of energy and electricity demand, electricity



generating system expansion planning, integrated energy system planning and GHG mitigation assessment.

The restructuring of electricity systems around the world has led to national electric utilities being privatized, independent power producers being allowed access to the system, and bidding based power markets to be opened to stimulate competition. The Agency has launched an effort to redesign its WASP expansion planning methodology to take account of these changes. Specifically, work began on developing electricity system planning tools that will provide information to Member States on how existing nuclear plants can compete in the new electricity market and how new nuclear units might fit into long term development plans.

Development was also completed of software (*B-Glad*) for estimating and valuing external costs associated with electricity generation. Designed for use in developing countries that cannot afford data intensive and costly analyses, the program runs on a PC and requires a minimum of data. It facilitates estimation of the environmental and external costs of electricity generation and helps users chart pollution mitigation strategies. This package of software and background information includes estimation and valuation techniques covering health and non-health damages from air, water and land pollution from fossil and nuclear energy generation technologies. The *B-Glad* package is available on CD-ROM for teaching purposes. Controlled field testing was begun in June through a CRP; the complete package, including a refined hydropower component, will be available for distribution by the end of 2000.

Peer review of the Reference Technology Database (RTDB), which contains information on technical, economic and environmental aspects of various components of energy chains, was finalized within the framework of the interagency DECADES project. Feedback from Member States using the DECADES tools resulted in two major improvements to the DECPAC software for comparative assessment. Specifically, the enhanced Pollution Control Devices submodule and the interface for the VALORAGUA model were integrated with the DECADES tools to permit better modelling of air pollution mitigation strategies and of electricity systems with an important share of hydropower.

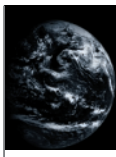
A 'multi source' version of the *EcoSense* model was developed to estimate pollution related health and environmental impacts and associated external costs using the extended pathway methodology. This approach takes account of all sources of pollution for a country or region in one model run. The model was integrated with the Agency's DECADES tools to permit extended analysis of different strategies for electricity generation.

It is important that nuclear power receives fair consideration in the international debate

Distribution of Agency Computer Models in 1999

	Number of releases of planning model or package					
	DECADES	MAED	WASP	ENPEP	FINPLAN	VALORAGUA
Member States	45	68	97	59	22	44
International organizations	8	7	12	6	—	3
Totals	53	75	109	65	22	47

DECADES: Databases and Methodologies for Comparative Assessment of Energy Sources; **ENPEP:** Energy and Power Evaluation Package; **FINPLAN:** Financial Planning model: **MAED:** Model for Analysis of Energy Demand; **VALORAGUA:** 'Valor Agua' (value of water); **WASP:** Wien Automatic System Planning Package. ■



on climate change, given its advantage of minimal GHG emissions. A CRP was initiated to study the role of nuclear power and other energy options in meeting international goals on GHG emission reductions, with three specific objectives: to enhance the Agency's tools for energy planning and comparative assessment so as to make them better suited for analysing issues related to GHG mitigation assessment; to develop methodological guidelines; and to provide the framework to conduct studies on the potential role of nuclear power in meeting international GHG emission reduction targets.

"The scientific forum at the 43rd General Conference explored the compatibility of nuclear power with sustainable development objectives."

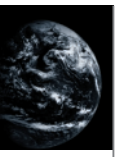
The scientific forum at the 43rd General Conference session in September was entitled 'Sustainable Development: A Role for Nuclear Power?' The forum explored the key question of the compatibility of nuclear power with sustainable development objectives. Views differed on what is meant by 'sustainability', with no conclusion being reached on the bases for judging nuclear power in this context; there was a strong sentiment in favour of developing a common set of criteria (e.g. emission levels, economics) for all energy generation systems. The question of the inevitable trade-offs between these criteria was raised, but was not resolved. The issue of global climate change was extensively discussed, and there were significant disagreements as to whether this would become the justification for nuclear power's expansion, or whether it would have any material impact on the predominantly economic criteria currently being used. As regards the economics of nuclear power, existing plants fare generally well even in deregulated and liberalized markets. In contrast, new nuclear plants face stiff competition from natural gas and coal and their competitiveness is limited to locations without easy access to gas or coal. What emerged from the various presentations was a common view that electricity use would expand greatly. However, there were vastly divergent views on the role nuclear power would (or should) play in meeting this growth. Fundamental to the entire debate, as pointed out by a number of speakers, is that nuclear power has to become competitive in its own right and must not rely on the introduction of environmental taxes or GHG emission constraints. This and the continued maintenance of the highest level of safety were seen as the most important ingredients for nuclear power to contribute to sustainable energy development.

Preparation of Part 1 of the *Nuclear Technology Review*, suggested at the March meeting of the Board of Governors, was completed. In addition to a brief summary covering the major nuclear energy events of 1999, the review explores the prospects of nuclear power in the years and decades ahead. The issues examined include cost and competitiveness, public confidence and acceptance, and sustainable energy development.

The Agency continued its analytical efforts in relation to the work of the Intergovernmental Panel on Climate Change, the United Nations Framework Convention on Climate Change and the World Energy Assessment — a joint effort of UNDP, the United Nations Department of Economic and Social Affairs and the World Energy Council. This assessment will be an important United Nations input to UNCSD-9 in 2001. The Agency's contribution to this assessment was the preparation of a chapter on energy resources.

SUPPORT TO MEMBER STATES

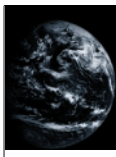
Capacity building activities in developing countries are an integral part of sustainable energy development. In this regard, the Agency seeks to enhance the capabilities of Member States to assess their energy and electricity expansion options by providing state-of-the-art methodologies and decision making tools. It has also had to respond flexibly in terms of its decision aiding tools and its training curricula to the new realities brought



about by market liberalization, deregulation and shrinking government budgets. Such assistance was provided though national technical co-operation projects in Brazil, Bulgaria, Croatia, Egypt, Lithuania, Mexico, Moldova, Poland, Slovenia, Sudan and Viet Nam. In all these countries, the focus was on assessing the role of nuclear power and other energy options in the future expansion of the electricity supply systems in these countries.

Regional projects in Europe, Asia and the South Pacific also addressed needs of Member States in the area of comparative assessment for sustainable energy development. An example is a technical co-operation Model Project that was initiated in Poland to establish a clearly defined energy planning framework and to assess the economic competitiveness and environmental impact of different energy options, including nuclear power and natural gas. The goal is to help build a national team of experts capable of assessing different energy options. Various scenarios of energy system development will be compared in order to identify those which meet national objectives related to energy diversification, costs, reliability and environmental impact.

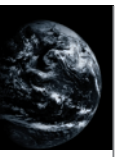
Another example is a national technical co-operation project on a pre-feasibility study on the introduction of nuclear power. Two national working groups were formed under the project, the first being responsible for utilizing the Agency's energy planning tools (MAED, WASP and ENPEP) to forecast energy/electricity demand, develop economically optimal expansion plans for the electricity system, and quantify environmental burdens associated with alternative electricity system expansion plans. The second group is investigating technical, safety and infrastructure development issues related to the introduction of nuclear power.



FOOD AND AGRICULTURE

PROGRAMME OBJECTIVE

To promote sustainable food security by fostering the development and transfer of nuclear and related biotechnological methods which provide significant opportunities for intensifying crop and livestock production, enhancing biodiversity and improving food quality and safety.



OVERVIEW

Progress was made in this programme in developing technologies and formulating environmentally sound practices for enhancing food security. Isotope and radiation techniques provided new scientific information on nitrogen fertilizer and water use by wheat, leading to practices which improved or maintained yields while saving on nitrogen fertilizer applications and reducing nitrate pollution of groundwater. Mutation techniques combined with modern biotechnology led to the generation of economically useful traits in crop plants. The use of radioimmunoassay (RIA) and related methods provided Member States with recommendations for improving artificial insemination, increasing milk production and controlling important livestock diseases. The sterile insect technique (SIT) continued to play a major role in the control and eradication of pests of both crops and livestock, while the role of irradiation as a sanitary and phytosanitary treatment of food and agricultural commodities continued to gain recognition. Finally, the FAO/IAEA Training and Reference Centre for Food and Pesticide Control at the Agency's Laboratories in Seibersdorf strengthened its assistance to Member States in the area of food quality and safety.

SOIL AND WATER MANAGEMENT AND CROP NUTRITION

A CRP on the use of nuclear techniques for increasing nitrogen fertilizer efficiency for irrigated wheat, and involving Afghanistan, Chile, China, Egypt,

India, Mexico, Nepal, Pakistan and the Syrian Arab Republic, was completed. Despite the shortage of water and the increasing cost of fertilizer, farmers tend to use excessive amounts of both resources in an attempt to maximize crop production. This results in depletion of water reserves and nitrate pollution of groundwater. Nitrogen-15 labelled fertilizers were used to estimate fertilizer recovery by crops and nitrogen losses, while a soil moisture neutron probe was used to assess the soil water balance and crop evapotranspiration. The timing of fertilizer application was critical in determining effectiveness. Application of nitrogen fertilizer at the locally recommended rate in two splits (one third at tillering and two thirds at the elongation stage of wheat), resulted in significant losses, especially during the first split, with a recovery of only 35%. The recovery during the second split was 62%. By reducing fertilizer application to 20% in the first split and increasing the second split to 80% of the annual rate, nitrate leaching was reduced and fertilizer use efficiency increased. A realistic increase of 5% of the overall nitrogen fertilizer recovery corresponds to annual savings of approximately $100 million for developing countries producing wheat. Irrigation was well managed in all but two of the countries mentioned earlier, where nitrate leaching was observed during the cropping season and better management could save 30% of current usage. A decision support system, incorporating the CERES-wheat model, was able to explain differences in wheat yield between countries, and to predict the effect of fertilizer timing on crop uptake and irrigation water usage on nitrate leaching.

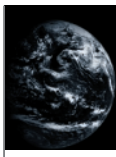
An interregional technical co-operation project on external quality assurance in total nitrogen and nitrogen-15 isotope ratio analysis by optical emission spectroscopy was completed by the Agency's Laboratories at Seibersdorf. The objective of the project was to identify a network of regional laboratories capable of carrying out precise and accurate analyses. Institutes in Argentina, Chile, Côte d'Ivoire, Guatemala, Malaysia, Mexico, Syrian Arab Republic, Thailand and Uruguay fully complied with requirements and can be recommended to act as regional network laboratories. The identification of proficient laboratories underpins attempts to increase nitrogen fertilizer use efficiency in developing countries, which used more than 50 million tonnes in 1996 worth $15 billion.

PLANT BREEDING AND GENETICS

Through a CRP on the improvement of new and traditional industrial crops by induced mutations and related biotechnology, major achievements were recorded on modifying agronomic traits, improving yield and modifying the oil quality in crops providing oilseeds and fibre. For example, advanced breeding lines of soybean with increased yield potential and improved quality of seed for oil and meal used in the food and feed industries were developed, while linseed and *Cuphea* mutants with new oil composition were created with potential use as renewable energy sources ('biodiesel'). Also, sunflower lines were selected with very high oleic content (suitable for use as frying oil), new lines of cotton were produced with shorter growing cycles and improved fibre yields, and new sources for pest and disease resistance were identified in rapeseed, mustard, sunflower and cotton. The development of molecular markers for soybean, sunflower, *Cuphea* and cotton and the isolation and transfer of genes related to specific oil qualities, pest resistance and drought tolerance were also achieved through this CRP. In addition, the exchange of germplasm, isolated genes and DNA sequences among participating countries was carried out.

Ninety-three new accessions were registered in the FAO/IAEA database for officially released mutant varieties. The total number has grown to 1961 mutant varieties of more than 163 species released in 62 countries.

In order to improve the probability of selecting disease resistant banana and plantain mutant plants, which is currently hampered by chimerism, the in vitro mutagenesis of multicellular meristems was simulated in the Agency's Laboratories at Seibersdorf by inducing mixoploidy and using flow cytometry



for detection. This approach made it possible to monitor and understand chimerism dissociation using different propagation methods. Multi-apexing proved the most efficient method, reducing chimerism from 100 to 7% after three subcultures.

Doubled haploid techniques, such as anther culture, were also used to accelerate the identification of recessive mutants and to purify selected mutants in rice. In the variety 'Taipei 309', pollen embryogenesis was much higher in cultivated anthers derived from the second crop of donor plants after harvest of the main crop, than in anthers derived from the first crop.

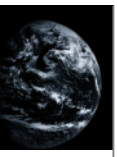
"Through a CRP, major achievements were recorded on modifying agronomic traits, improving yield and modifying the oil quality in crops providing oilseeds and fibre."

An FAO/IAEA seminar, organized in October in Manila, focused on the current status and future direction of mutation techniques and related molecular genetic approaches for plant research and crop improvement. The presentations by participants clearly demonstrated the significant progress and impact of mutation techniques in the development and utilization of improved varieties of various economically important crops in the region. It was agreed that mutation techniques should be used not only for the improvement of major crops, but also for the domestication of crops with economic potential. The integration of related molecular genetic techniques in the characterization of mutant derived lines and varieties illustrates the potential of these techniques in complementing and accelerating breeding programmes through marker aided selection, diversity analysis and fingerprinting for plant variety protection. In order to transfer recent molecular and mutation techniques more widely and efficiently to crop improvement programmes in the region, the Agency was requested to provide training and information on these subjects.

ANIMAL PRODUCTION AND HEALTH

A CRP on the use of RIA and related techniques to identify ways of improving artificial insemination (AI) programmes for cattle reared under tropical and subtropical conditions resulted in a unique international database on the current status of AI in 14 Member States in Asia and Latin America. Conducted on nearly 2000 farms and covering some 11 000 artificial inseminations on over 7000 cows, the study showed that conception rates following AI were often far lower than generally presumed by many organizations which provide these services. On average, 17% of cows (up to 40% in some locations) were mated at an inappropriate time in relation to oestrus. Even in those mated correctly, 25–50% of animals either did not conceive or suffered death of the embryo within two months. This is a waste of available resources and results in economic losses to farmers. The problems which need to be addressed by providers of AI services as well as farmers were identified, improvement strategies were tested and the responses monitored. In Sri Lanka, for example, the introduction of improved reproductive management by farmers combined with more efficient AI services increased the proportion of cows in lactation at a given time by 20%, annual milk production by 30% and the net profit to farmers by 40%. This CRP also resulted in the development and standardization of methodologies — including a software program 'AIDA' (Artificial Insemination Database Application) — which are now being applied on a wider scale in these as well as other Member States through regional and national technical co-operation projects in Asia, Africa and Latin America.

Contributing to the wider application of progesterone RIA for field level problem solving and provision of diagnostic services of direct benefit to farmers, the Agency's Laboratories at Seibersdorf developed a novel 'self-coating' RIA system based on a monoclonal antibody to progesterone. This dramatically reduces the



cost of assaying milk samples and facilitates development of the capability to produce the essential reagents in selected national laboratories of Member States. Training and infrastructure development to achieve self-sufficiency in RIA requirements within each geographical region and promote the sustainability of applications to improve livestock production was conducted through technical co-operation projects.

Foot and mouth disease remains one of the most serious threats facing livestock production and trade. A CRP designed to improve diagnosis of this disease in Asia and to monitor control and eradication efforts was completed. Involving national veterinary laboratories in the region, this CRP led to the development, validation and standardization of specific and sensitive diagnostic tests. The proficiency of the laboratories involved was verified through the operation of an external quality assurance exercise. Major outcomes of the development of this diagnostic capability across the region were the initiation of a multi-donor control and eradication programme for foot and mouth disease in Asia and the completion of a regional high security reference laboratory in Thailand for this disease.

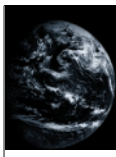
INSECT AND PEST CONTROL

As a result of an SIT technical co-operation Model Project in Argentina on fruit fly eradication, major economic benefits were achieved in the Provinces of Rio Negro, Neuquen and Mendoza. Not only did insecticide applications decrease greatly in commercial fruit orchards, but the quantity and quality of temperate fruit production increased significantly since the start of the project, and several fruit producing valleys were declared fruit fly free. Most importantly, this work resulted in the neighbouring country of Chile, already recognized internationally as fruit fly free from a previous SIT project, allowing the fruit industries in Mendoza and Patagonia Provinces to use Chilean ports for their fruit exports. Fruit exports from Argentina already amount to approximately $0.5 billion annually, and this access to the export markets of Pacific Rim countries through Chile should bring further major economic benefits to Argentina's fruit industry.

Progress was made in an SIT technical co-operation project in the Middle East, where sterile Mediterranean fruit fly males were released over the Arava region of both Jordan and Israel with the objective of developing internationally recognized fly free areas to allow fruit and vegetable exports. The sensitive logistical issues involved in the long distance shipment of sterile males to the region and aerial releases over both countries were satisfactorily resolved and significant economic benefits have been derived from the establishment of fly free areas. The impact can be measured by the fact that six agricultural areas have now been designated as fly free and a fifty fold increase in the economic value of vegetable exports was achieved. The success of this pilot project and the environmental benefits of reduced insecticide use led to preparations to expand area-wide medfly control using SIT northward into Gaza and to agricultural areas of Israel and Jordan.

"The Agency's Laboratories at Seibersdorf developed a novel 'self-coating' RIA system that dramatically reduces the cost of assaying milk samples."

Weekly sterile screwworm fly releases were initiated over Jamaica. This was the culmination of intensive preparatory work involving the establishment of a 'National Screwworm Eradication Project', economic and environmental assessments, staff training, baseline data collection and infrastructure development. With eradication activities now in progress, the prospects for eradication of this major livestock pest from Jamaica appear promising. Preparatory activities were initiated for a similar eradication project in Cuba, which together with the Dominican Republic,



is the last area in the northern half of the Western Hemisphere where this pest is currently present.

A new medfly genetic sexing strain was produced at the Agency's Laboratories at Seibersdorf. This strain contains genetic material from many different medfly populations and utilizes a translocation that both increases stability during mass rearing and alleviates some of the quality control problems associated with previous genetic sexing strains. The strain was shipped to medfly SIT programmes in South Africa and Australia for further testing, and it will be provided to facilities in Argentina, Chile, Guatemala, Portugal and the USA.

"The capabilities of national food control authorities in developing Member States for analysing food contaminants continued to be strengthened through the FAO/IAEA Training and Reference Centre for Food and Pesticide Control."

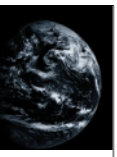
A prototype tsetse rearing unit designed to reduce the cost of tsetse mass rearing was shipped to three facilities in Africa for evaluation under local conditions using different species of tsetse. This unit is a refinement of an earlier unit developed at the Agency's Laboratories at Seibersdorf. Essential to the operation of the unit is a simple protocol for the introduction of the correct number and sex of flies into production cages. This protocol was fully evaluated and introduced into routine colony maintenance at Seibersdorf, with major savings in time and labour.

FOOD AND ENVIRONMENTAL PROTECTION

An international conference on ensuring the safety and quality of food through radiation processing was held in Antalya, Turkey, in October to assess the current status and future prospects for food irradiation. It was convened at a time when there is increasing acceptance and application of irradiation as a sanitary and phytosanitary treatment of food and agricultural commodities and also at a time when the widespread and increasing incidence of foodborne illnesses, caused by pathogenic bacteria and parasites, has brought the issue of food safety to the forefront of public health concerns. The conference reaffirmed that the safety and nutritional adequacy of irradiated food produced under conditions of good manufacturing practices, are no longer in question regardless of the absorbed dose. It was also agreed that irradiation as a cold pasteurization/decontamination treatment of food, both of animal and plant origin, is an essential step in the Hazard Analysis Critical Control Point based approach being widely applied or even mandated in many countries to ensure its safety.

New developments in food and environmental protection included co-operation between countries in Asia and the Pacific through RCA, resulting in the adoption of a harmonized protocol on irradiation as a quarantine treatment of fresh horticultural commodities and the development of guidelines on irradiation as a phytosanitary treatment. The protocol and guidelines will be submitted to the Secretariat of the International Plant Protection Convention for elaboration into an international standard. Another development was the progress made by a number of Asian countries in using this technology on a commercial scale. And new or additional commercial irradiation facilities are under construction in Bangladesh, China, India, the Republic of Korea and Thailand.

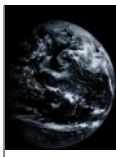
The mandate of the International Consultative Group on Food Irradiation (ICGFI) was extended until 2002 to strengthen involvement of the food industry in its work and to facilitate the dissemination of information to the public on the safety and benefits of food irradiation. At the request of ICGFI, the FAO/WHO Codex Alimentarius Commission initiated steps to amend the current Codex General Standard for Irradiated Foods with



the aim of removing the upper dose limit of 10 kGy.

A CRP assessed the effects of repeated and long term applications of pesticides on the properties of soils, including their effects on microbial populations and biochemical processes, binding and release of pesticide residues, and the mineralization of pesticides. The radiotracer technique involved the use of carbon-14 labelled compounds. The results indicated that some pesticides temporarily inhibited microbial growth and various biochemical processes in the soil, whereas others were stimulatory. All applications caused an increase in the amount of soil bound residues with the passage of time. Also, mineralization of radiolabelled pesticides was reduced in soils receiving repeated applications of pesticides. The information obtained will be used to assist Member States develop better pest management strategies.

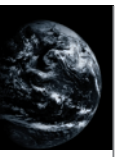
The capabilities of national food control authorities in developing Member States for analysing food contaminants continued to be strengthened through the FAO/IAEA Training and Reference Centre for Food and Pesticide Control at the Agency's Laboratories at Seibersdorf. Examples of the support provided by the centre included: the organization of an RCA workshop in the Philippines and an interregional FAO/IAEA training course at Seibersdorf on quality assurance procedures for mycotoxin and pesticide residue analyses; the establishment of an International Food Contaminant and Residue Information System to provide up to date information through the Internet (*http://www.INFOCRIS.iaea.org*) on sampling and analytical methods for food contaminants affecting trade in food and agricultural commodities; and the development of simpler multi-residue analytical methods. In addition, a workshop on the principles and practices of method validation was held in Hungary to develop guidelines for single laboratory validation of methods for the analysis of trace organic compounds. These guidelines will be considered at the upcoming sessions of the Codex Committees on Pesticide Residues and on Veterinary Drug Residues for development into Codex standards.



HUMAN HEALTH

PROGRAMME OBJECTIVE

To enhance the capabilities of developing Member States to address important health problems through the development and application of nuclear and related techniques in areas where they confer advantage in comparison with conventional techniques or by themselves constitute the conventional technique.



OVERVIEW

The main thrust of the programme continued to be cancer control and combating infection and malnutrition through preventive measures. In nuclear medicine, emphasis was placed on cost efficacy studies of inexpensive radiopharmaceuticals and the application of isotopes in molecular biology and new radioimmunoassay related procedures. In radiation therapy and radiobiology, development of quality assurance was the main topic and included the development of patient immobilization devices and protocols for cancer patients with HIV infection. In October, the Agency was invited to sign the 'Mutual Recognition Arrangement' for metrology institutes with the Comité International des Poids et Mesures (CIPM). The main benefits are expected to be improved intercomparison and quality audits organized by the Agency for Secondary Standard Dosimetry Laboratories (SSDLs). In the area of health related environmental studies, new strategies for nutrition intervention schemes were identified and the global network of analytical laboratories was strengthened.

NUCLEAR MEDICINE

Efforts continued in 1999 on enhancing the awareness and capabilities of Member States in the efficient and cost effective use of in vitro and in vivo nuclear medicine technology for managing their critical health problems, and for undertaking basic and clinical research in relevant subjects. For example, special emphasis was placed on: the development of in vivo and in vitro

diagnostic methods, and treatment procedures with open sources of radioactivity; optimization of the cost effectiveness of health care using nuclear medicine procedures, development of multimedia and Internet based teaching aids; and transfer of technology to developing Member States on the management of a number of clinical problems, including viral hepatitis, genetic disorders, coronary artery disease, infection, cancer and paediatric disorders.

A new radiopharmaceutical using a bacterially binding radiolabelled antibiotic was evaluated in a CRP as a bacterial specific imaging agent (technetium-99m–Infecton, a Ciprofloxacin derivative which binds to DNA gyrase of living bacteria for the detection of active infection). The multi-centre study, which was concluded in 1999, yielded a sensitivity of 85% and specificity of 83% for detecting bacterial infections.

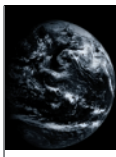
A regional CRP entitled 'Standardization of Iodine-131 Treatment for Hyperthyroidism with an Intent to Optimize Radiation Dose and Treatment Response' was concluded. In a prospective randomized therapeutic trial based on the absorbed dose concept, 900 patients suffering from hyperthyroidism were treated with iodine-131 (90 or 60 Gy). The best results were obtained in the high dose (90 Gy) group. It was also observed that a significant reduction in the administered activity of iodine-131 is possible with adjuvant lithium intervention.

An earlier CRP assisted some Member States in developing their own capability to produce samarium-153 from indigenously available reactors. The sequel to this was a new clinical CRP to evaluate the efficacy and toxicity of samarium-153 EDTMP in the palliation of painful skeletal metastases. Analyses of data from 417 patients who were treated and followed up for 16 weeks revealed significant pain palliation in 73% of the patients ('responders'), with only minimal or mild haematological effects and no systemic toxicity. In addition, for 82% of the responders, post-therapy analgesic intake was substantially reduced or stopped completely, which is considered highly cost effective in the management of such patients.

Nuclear medicine technology transferred to developing Member States through technical co-operation projects included:

- The use of radioisotope labelled DNA probes and primers to identify families with fragile x syndrome and myotonic dystrophy in Costa Rica. Seventeen families with this syndrome were identified, from which 73 individuals participated in the diagnostic tests, while 18 families with myotonic dystrophy were identified out of which 72 individuals were tested. The affected individuals were counselled about their risk of having a child with these complications.
- Transfer of PS2 IRMA and oestrogen receptor methodologies, developed within a CRP on tissue diagnosis of breast cancer, to participants from ten countries in an East Asian regional training course.
- Transfer of a new, low cost, synthetic peptide-based, anti-hepatitis C virus screening method, developed indigenously in Costa Rica, to seven countries in the Latin America region.
- Development of a new protection free version of the Portable Image Processing software. This software is used in more than 300 nuclear medicine centres for various clinical applications, in projects on upgrading gamma cameras with standard PCs and in training on image acquisition and processing in nuclear medicine.
- Production of a video tape on single head scintillation camera quality control, which was used in various training activities. This complements an Agency technical document on the quality control of nuclear medicine instruments (IAEA-TECDOC-602).
- Extension of the distant assisted training programme for nuclear medicine technologists to the African and Latin American regions.

With a view to integrating nuclear medicine services into health care systems, and to promote uniformity and standardization with respect to infrastructure development, teaching, training, patient care and research, an Advisory Group meeting was organized to prepare a resource manual in nuclear



medicine on the basis of the Agency's Safety Standards publications.

APPLIED RADIATION BIOLOGY AND RADIOTHERAPY

Attention continued to be focused on developing country needs by: assisting them in identifying and acquiring techniques for curative and palliative cancer treatment with radiation; promoting clinical quality assurance in all aspects of patient management; and continually upgrading the Agency's available information on current techniques in radiation oncology to identify those with the potential for wider dissemination. All of these activities were fully integrated into the Agency's technical co-operation programme, primarily through regional projects.

"A handbook was produced to illustrate the use of cost effective patient immobilization devices that were developed and distributed by the Agency."

A handbook was produced to illustrate the use of cost effective patient immobilization devices that were developed and distributed by the Agency in 1998. The handbook was also distributed through related technical co-operation projects. In addition, an interregional workshop was held in Tunisia on the proper use of this equipment.

An Advisory Group meeting was held in Vienna in October on the role of radiotherapy in AIDS patients. This is a subject of great importance in sub-Saharan Africa, where HIV positivity can exceed 25% in some population groups. The disease is accompanied by a greater than five fold increase in many cancers, including Kaposi's sarcoma, non-Hodgkin's lymphoma, squamous cancer of the conjunctiva and Hodgkin's disease. Decision making (including the option of not administering any treatment at all) in the radiotherapy management of patients infected with HIV who have limited life expectancy attributable to AIDS alone was addressed and a document prepared for clinical guidance. This work was facilitated by the provision of epidemiological data on the cancer increases by WHO/IARC.

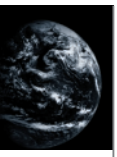
Work on clinical protocols specifically for developing countries in the radiotherapeutic management of advanced cervical cancer, disseminated bone metastases and advanced oesophagus cancer made progress. The last method won a prize as the best innovative protocol at the European Society Congress of Brachytherapy. The selection of patients has now ended and the preliminary results appear to be satisfactory. Final analysis and publication of the results is expected in 2000.

An Advisory Group meeting, held in Vienna in April, on a microsource high dose rate afterloading system examined the advantages of these very small source brachytherapy devices. The main result was the significant change that was seen in both developed and developing countries in the use of these machines in preference to low dose rate (LDR) machines. This is because brachytherapy treatment can be given on an outpatient basis using these machines, instead of the usual two to three day hospital stay required for LDR.

In high technology radiation therapy, a Technical Committee meeting was held to evaluate the present status of boron neutron capture therapy. The meeting examined the current status after 50 years of efforts to use reactor neutron interaction with boron for the treatment of brain and other malignant tumours. The conclusion was that notwithstanding improvements in delivery techniques of the neutron beam, the results to date have not demonstrated any clinical benefit to justify elevating this technique to more than investigational level.

DOSIMETRY AND MEDICAL RADIATION PHYSICS

Following an invitation by the CIPM, the Agency signed the 'Mutual Recognition of



National Measurement Standards and of the Calibration and Measurement Certificates Issued by National Metrology Institutes' (the 'Mutual Recognition Arrangement', or MRA) for the IAEA/WHO Network of SSDLs. The signing of the MRA places the metrology of ionizing radiation in those developing countries having a laboratory that is a member of the SSDL Network at a level of international recognition that has no precedent in the past, allowing for the worldwide recognition of their standards and calibration certificates. This, naturally, imposes strict demands on the performance of the SSDLs, and will require a tightening of the conditions of acceptability of results of the intercomparisons and quality audits organized by the Agency for the SSDLs.

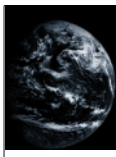
The IAEA/WHO SSDL Network currently includes 70 laboratory members and 6 SSDL national organizations in 59 Member States; the Network also includes 15 affiliated Primary Standard Dosimeter Laboratories (PSDLs), and five collaborating international organizations. An SSDL in Viet Nam was established under the framework of a technical co-operation project and admitted as a new member of the SSDL Network.

A total of 70 national standards and reference ionization chambers were calibrated at the Agency for Member States: about 80% were radiotherapy level calibrations and 20% were for radiation protection. The establishment of measurement standards at the Agency for diagnostic radiology beams used in mammography was also completed. The Agency reference standard was calibrated at PTB, the German standards laboratory, and calibration services of measuring instruments for mammography were made available to Member States.

Dose quality audits and intercomparisons were organized for SSDLs in order to check the traceability of their measurements and to monitor their performance. Nine SSDLs participated in the intercomparisons of radiotherapy ionization chamber calibration factors and 25 in the thermoluminescent dosimeter (TLD) audit for radiation protection level dosimetry; 123 radiation beams from cobalt-60 units and clinical accelerators at laboratories, or supervised by SSDLs, were reviewed in the TLD audit for radiotherapy. Procedures for the intercomparison of calibration factors at therapy and diagnostic radiology (mammography) levels, within a project of the European Organization for Metrology in 2000, were developed jointly with German and Austrian PSDLs.

A survey was carried out of the activities of members of the SSDL Network. The results indicated that about 70% of laboratories are involved in quality assurance programmes for radiotherapy through postal TLD services or site visits to hospitals. Also, about 30% of the SSDLs have started to calibrate brachytherapy sources and equipment, and an additional 20% will soon start this activity. In the field of X ray dosimetry, 40% of the SSDLs are calibrating instruments for diagnostic radiology.

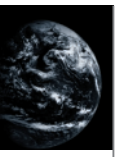
The IAEA/WHO TLD postal dose assurance service for monitoring the calibration of radiotherapy beams at hospitals worldwide audited 377 beams, of which 228 were cobalt-60 and 149 were high energy X rays from clinical accelerators. The percentage of the deviations within the ±5% acceptance limits has increased from approximately 65% in the past (81% in 1998) to 87%. For results outside the ±5% limits, the Agency had established a regular follow-up programme, contacting the hospitals either directly or through WHO (PAHO) for tracing the reasons for the discrepancy and performing repetitive TLD irradiations. Analysis of this follow-up programme has shown that 39% of the hospitals have improved their results in the follow-up irradiation, but 18% of the discrepancies still persisted. As a result, the Agency is in the process of establishing a mechanism to investigate and resolve these persistent TLD deviations and determine why some follow-up TLDs have not been returned for the analysis. The analysis also revealed the limitations for hospitals that do not participate regularly in external audits: 102 radiotherapy facilities in 92 hospitals, mainly from Eastern Europe and Asia, which had never been audited before were included in the IAEA/WHO TLD programme, with the finding that only 65% of the results of a first participation are within the ±5% limits.



Following positive feedback on Agency assistance in setting up national TLD programmes for quality assurance in radiotherapy at the national level, five new countries were helped in starting national programmes within the framework of a CRP. And as part of a technical co-operation project in Central American and Caribbean countries, a network for reciprocal on-site quality audit visits was established where physicists from the different radiotherapy institutions of the region can carry out quality control measurements in other hospitals and countries.

Seventy-three cobalt-60 and three electron beam checks were performed for industrial facilities and research institutes in Member States through the International Dose Assurance Service.

A regional technical co-operation project for establishing a common Master's degree in medical physics in Latin America was initiated. The course will run consecutively in several national universities and has just been started in Venezuela after a written examination for regional candidates. Agency supported Fellows from the region will participate in the courses, which will be taught by an international panel of professors using a common syllabus.



NUTRITIONAL AND HEALTH RELATED ENVIRONMENTAL STUDIES

Nuclear and isotopic techniques were used to improve nutrition monitoring techniques and to identify effective strategies in nutrition intervention schemes, particularly among vulnerable groups, in developing regions around the world. In this connection, a draft thematic plan entitled 'Isotopic Evaluations to Add Value to Nutritional Interventions' was developed as a template for new regional technical co-operation projects in the Latin America and East Asia and Pacific regions. The project in Latin America focuses on the use of isotopes for evaluating nutrition intervention programmes. The East Asia and Pacific project has as its major goal the measurement of the effectiveness of multinutrient supplementation using stable isotopic techniques.

An assessment of vitamin A body stores and the bioavailability of pro-vitamin A was performed using in vivo kinetics and the 2H-retinol method in developing countries. The results provided a more accurate picture of whole body retinol stores and vitamin A status in mothers and children. This isotopic technique can be used to monitor vitamin A status when measuring the effectiveness of vitamin A supplementation programmes. In addition, a CRP on the development and application of isotopic techniques in studies of vitamin A nutrition was completed. The main conclusion was that under conditions of vitamin A supplementation for food fortification and dietary improvement, the isotope dilution technique using deuterated vitamin A proved to be a less invasive technique than earlier traditional approaches used to assess body stores, such as direct measurement of vitamin A in liver biopsies. Along with other conventional methods, namely serum retinol determination and conjuctival impression cytology, this technique

Lichens and Mosses — A Biomonitor for Environmental Pollution

Lichens and some lower plants have no roots and absorb their nutrients directly from the air. If the material absorbed is not metabolized, which is the case for many heavy metals (radioactive or stable), they accumulate in these organs over time. A CRP was conducted to evaluate the suitability of various organisms as biomonitors for trace element atmospheric deposition. As a result, several types of mosses, lichens and lower plants have been identified in different climate regions as appropriate organisms for monitoring long term air pollution status in the areas under investigation. Nuclear and related analytical techniques were used to demonstrate the presence of non-radioactive environmental pollutants. In support of the required analytical quality control, an interlaboratory comparison study on lichen samples was also carried out. ■

provides a more accurate assessment of vitamin A status, particularly in vulnerable groups such as children, and pregnant and lactating women.

The deuterium kinetics technique was established for measuring breast milk intake and body composition using both infrared spectroscopy and isotope ratio mass spectrometry. A technical co-operation Model Project in Senegal has successfully introduced this technique in the field and has been providing assistance to other African countries. In addition, as a result of a CRP on the isotopic evaluations of maternal and child nutrition to help prevent stunting, this technique has been extensively used in Latin American countries and in Pakistan, and is also being used in a new CRP on isotopic evaluations in infant growth monitoring, in collaboration with the WHO Growth Monitoring Programme.

Reports by WHO and other international organizations indicate that chronic diseases associated with ageing are becoming a serious problem in many developing countries, especially those undergoing nutritional and demographic change. In order to identify the mechanisms of disease development so as to define better methods of prevention, a CRP was initiated on the application of nuclear techniques in degenerative diseases in ageing. The first Research Co-ordination meeting was held in Vienna in May, where a protocol on the standardization of nuclear and isotopic techniques, including homeostatic model assessment to measure insulin sensitivity and methodologies for assessing body composition, substrate and energy metabolism, was developed.

An Advisory Group meeting on nutrition that included scientists from developed and developing countries, WHO and the Trace Element Institute for UNESCO took place in November. The purpose was to review the status of the Agency's work in nutrition, and to develop specific recommendations on expanding the application of isotopic techniques in human health areas for future projects and activities.

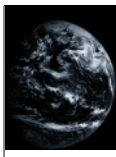
A global network of monitoring stations for determining elemental content in the PM_{10} and $PM_{2.5}$ fractions of airborne particulate matter was established through two CRPs. Health related epidemiological studies were carried out in these projects with the aim of linking results of chemical analyses with pulmonary and other diseases found in exposed general populations or exposed workers.

In support of analytical quality control efforts, an interlaboratory comparison for the determination of minor and trace elements in urban dusts (namely Vienna Dust and Prague Dust), artificially loaded on air filters (for evaluation of heterogeneity) was carried out using a range of analytical techniques. A large number of loaded filters was prepared and characterized for use in future proficiency testing for the participating laboratories.

"In a CRP on the application of nuclear techniques in degenerative diseases in ageing, a protocol on the standardization of nuclear and isotopic techniques was developed."

The Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA) network was placed on a more formal footing by the issuance of letters of invitation to Member States to nominate one or more laboratories. More than 40 countries responded, nominating a total of 74 laboratories for the network. The first proficiency test involving the analysis of plutonium, americium, strontium-90 and gamma emitting radionuclides was initiated.

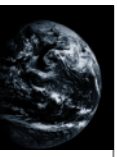
In support of analytical quality assurance for environmental studies, two lichen materials, IAEA-336 and IAEA-338, were characterized for their element content using various analytical techniques. Analyses for various trace elements for certification of a Japanese Diet Reference Material were carried out in support of the CRP on Reference Asian Man.



MARINE ENVIRONMENT, WATER RESOURCES AND INDUSTRY

PROGRAMME OBJECTIVE

To improve Member State capabilities to: monitor and assess radioactivity in the marine environment for its protection, and use nuclear techniques and environmental isotopes to understand better and assess marine processes and pollution; integrate appropriate isotope and nuclear techniques in the planning and resource management of the water cycle, and better understand human induced hydroclimatic impacts; and adapt and utilize radiation and radiotracer technologies to improve industrial productivity and minimize environmental hazards.



OVERVIEW

The Agency's programme on the marine environment continued to focus on the protection of the oceans and coastal seas through radioactivity monitoring and assessment and the use of nuclear and isotopic techniques to understand the fate and behaviour of pollutants. Capacity building, quality assurance, the provision of reference materials and methods, training and participation in cruises to collect marine samples in the Southern Ocean and along the coast of Morocco were among the most important of the Agency's contributions in 1999.

As part of its work in water resources management, the Agency developed an isotope methodology to assess groundwater renewal in areas where water is scarce. This will help Member States in the management of their water resources. Efforts to develop improved techniques for the measurement and interpretation of isotopic data continued, with specific water resource management issues in Member States addressed through the Agency's technical co-operation activities.

In the area of industrial applications, radiation processing techniques for making biomaterial and vulcanized rubber latex were promoted through

CRPs. Work focused on the use of electron beams for treating organic contaminated industrial effluents and polluted water, resulting in many pilot studies for possible large scale application. Documentation and training in non-destructive testing procedures and in the use of tracers and nucleonic gauges in industry were provided to developing Member States.

MEASUREMENT AND ASSESSMENT OF RADIONUCLIDES IN THE MARINE ENVIRONMENT

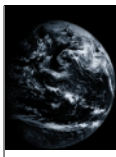
An innovative system for the monitoring of marine radioactivity using stationary gamma monitors with satellite data transmission was developed by IAEA-MEL. The new system was deployed in April in Monaco Bay to test its performance and to evaluate the results. This equipment can record and transmit information on gamma emitting radionuclides in sea water and on a suite of parameters, including sea water temperature, salinity, current speed and direction, and can generate long term continuous records of marine radioactivity at locations distributed throughout the world's oceans. This is of particular interest for assessing the impact of nuclear facilities in normal or emergency situations and for surveying radioactive waste dump sites, but can also be used for a sentinel system in coastal or open sea locations, fishing grounds, or along major shipping routes. The monitoring system performed well over an eight month testing period, reaching the projected sensitivity of 4 Bq/m^3 for caesium-137 concentration in water. It is planned to deploy the monitor in 2000 in the Irish Sea to investigate the long term transport of caesium-137 released from the Sellafield nuclear fuel reprocessing plant.

Within the framework of a project on Marine Radioactivity Studies in the World Oceans, supported by the Government of Japan, the Agency participated in the ANTARES IV expedition to the Southern Ocean organized by French institutes. Surface water samples and three water profiles down to a depth of 5000 m were collected, as well as samples of plankton and fish. The aim is to study the vertical movement of radionuclides in the ocean. Direct on-board analyses of short lived thorium-234 were carried out for the first time by IAEA-MEL, using the most recent techniques. Thorium-234/uranium-238 disequilibria were used to study particle transport from the upperphotic zone down to deeper waters.

During the first Research Co-ordination meeting for a CRP on worldwide marine radioactivity studies, a geographical information system was developed for the assessment of marine radioactivity in the world oceans and seas. Hydrogen-3, carbon-14, strontium-90, iodine-129, caesium-137, plutonium and americium isotopes were chosen as being representative of anthropogenic radionuclides in the marine environment, and their main distribution patterns were established. The evaluation of sources of anthropogenic marine radioactivity has shown that global fallout is still the dominant source in the oceans, although in some areas releases from nuclear fuel reprocessing plants (e.g. in the Irish and North Seas) and the Chernobyl accident (the Baltic and Black Seas) have exceeded the contributions from global fallout.

"An innovative system for the monitoring of marine radioactivity using stationary gamma monitors with satellite data transmission was developed by IAEA-MEL."

Radioanalytical analyses were completed on a wide variety of samples from the Indian and Pacific Oceans and the Caspian Sea. Uniform distributions of strontium-90, caesium-137, plutonium and americium isotopes were found in the north Indian Ocean, confirming that global fallout is the dominant source of anthropogenic marine radioactivity in this region. Higher activity ratios of plutonium-238/plutonium-239+240 observed in the Indian Ocean are due to plutonium-238 remnants in surface water from the SNAP satellite, which burned up at high altitude over the Mozambique Channel in 1964. By



comparing plutonium profiles in the water column from various expeditions to the northwest Pacific Ocean, it was possible to establish temporal and spatial trends in the concentrations and inventories of this element in sea water which show a considerable decrease with time. Plutonium sediment inventories calculated from data stored in the Global Marine Radioactivity Database indicate a latitudinal and longitudinal decrease from the Marshall Islands test sites to the central northwest Pacific Ocean, as well as the northeast Pacific. This is in agreement with previous observations that the northwest Pacific has been affected both by global (stratospheric) fallout and tropospheric fallout (from nuclear weapons tests carried out at Bikini and Enewetak Atolls, Marshall Islands), while the northeast Pacific shows only contributions from global fallout. Analyses of hydrogen-3, strontium-90, caesium-137, plutonium and americium isotopes in surface waters and in the water column of the Caspian Sea indicate that the deep basins of the sea are rapidly ventilated, with the estimated turnover time of the sea being approximately 200 years. The radionuclide levels observed in sea water can be explained by global fallout and, therefore, at the sampling sites visited there were no signs of extra sources of anthropogenic marine radioactivity.

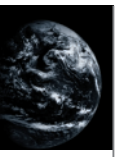
In the Agency's Analytical Quality Control Services (AQCS) programme for radionuclides in the marine environment, an intercomparison exercise on IAEA-384 Fangataufa lagoon sediment was completed and a reference material was issued which has been certified for 20 anthropogenic and natural radionuclides, increasing the total number of these materials to 38. These reference materials have been widely used by Member State laboratories for analytical quality assurance/quality control, development of new analytical methods and for training purposes.

Support to the Agency's technical co-operation programme included scientific and technical backup to the technical co-operation project 'Marine Environmental Assessment in the Black Sea Region'. Enhanced capabilities to assess marine radioactivity and to co-ordinate monitoring on a regional scale have been developed through this project. Furthermore, the project highlighted the lack of previous data from the Black Sea on natural polonium-210, which is the main deliverer of dose through marine exposure pathways. Using the capabilities developed through this project, new polonium-210 data have been acquired. Sediment chronologies were studied using the lead-210 dating technique in order to reconstruct the history of contamination in various areas of the Black Sea. The input of strontium-90 and caesium-137 into this sea through the major rivers has been determined, and monitoring was initiated at 14 points along the Black Sea coasts.

A new technical co-operation project on pollution monitoring in the marine environment is assessing the present situation of the contamination of the south Mediterranean Sea by radionuclides, heavy metals and organic compounds. Simultaneously, a regional capability within North African Member States to monitor marine pollution is being developed. Within the framework of this project, a joint Moroccan–IAEA cruise was organized to assess contaminants in sea water, biota and sediment along the coast of Morocco in the Atlantic Ocean and the Mediterranean Sea. In addition, high resolution profiles of physical and chemical parameters, such as conductivity, temperature, dissolved oxygen, and nitrate and nitrite in the water column were obtained from shipboard measurements carried out during the cruise.

TRANSFER OF RADIONUCLIDES IN THE MARINE ENVIRONMENT

Experimental nuclear application studies were focused on the use of radiotracers to assess the bioaccumulation, retention and transfer factors of radiologically important radionuclides and toxic heavy metals in marine organisms that are of global importance in oceanic food chains. The installation of new, state-of-the-art experimental aquaria systems at IAEA-MEL, which can simulate different marine ecosystems, has greatly facilitated radiotracer studies of species which are very difficult to maintain in captivity. One



such group are the cephalopods, or squid, a predator species which serves as a primary source of food for marine mammals and humans alike. To follow the uptake and distribution of radionuclides and metals in these ubiquitous animals, common cuttlefish were exposed to a mixture of radiotracers in water and in their food. Both exposure pathways led to a strong accumulation of contaminants in the organism's digestive gland. While such bioaccumulation and retention of contaminants in a non-consumable organ of cuttlefish would have little impact on the human population eating these cephalopods, top marine predators such as whales, which consume squid, may be exposed to elevated levels of toxic metals through their food chain. Such a transfer mechanism may account for the very high concentrations of cadmium and various heavy metals noted in whales and other marine mammals.

Another group of organisms currently the focus of interest are gelatinous plankton, or jellyfish, outbreaks of which cause difficulties for both the fisheries and tourism industries. Such attacks are thought to occur in areas under the impact of pollution and following changes in nutrient loads. Benthic and pelagic jellyfish were exposed under controlled experimental conditions to the same suite of metals and radionuclides which were subsequently accumulated and retained in their tissues. Most striking was the enhanced accumulation of silver by a bottom dwelling species, *Cassiopea*. This suggests that this particular species could be used as a bioindicator of silver contamination which, in turn, is a chemical marker for domestic sewage. Furthermore, this species of jellyfish obtains much of its nutrition through the photosynthesis of small plant cells located in its own tissues. Radiotracer studies carried out in the light and dark suggest that these cells may actually play a major role in the uptake and retention of these contaminants by the jellyfish.

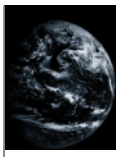
Lead is another toxic metal which, in areas like estuaries where large salinity variations are typical, can be released from particles into a dissolved, more bioavailable form. Estuarine shrimps exposed to lead-210 rapidly accumulated dissolved radiotracers reaching concentration factors as high as 100 after only two days. In the case of lead, nearly one-half of the amount taken up was located in the shrimp's exoskeleton which it periodically sheds as it grows. For surface reactive metals like lead, such a physiological mechanism can account for the low metal retention in this species of shrimp, and ultimately limited transfer of lead through the marine food chain to people.

The transfer and fate of toxic organic contaminants can also be assessed by nuclear techniques. For example, bottom dwelling sea stars and sea urchins were exposed to the highly toxic, carbon-14 labelled polychlorobiphenyl (PCB) congener No. 153 in sea water and in their natural food. It was found that the predominant uptake pathway was from water, and that this PCB congener was mainly concentrated in the body wall and tube feet rather than in internal organs. The radiotracer foodchain study also demonstrated that the nature of the contaminated food strongly influenced the degree of PCB assimilation into the animal and its subsequent distribution among the various tissues.

"Radiotracer methodologies offer great promise as a rapid and relatively inexpensive means for tracing contaminant behaviour and identifying target organs and tissues in specific marine species."

One of the most striking results to come out of all the laboratory radiotracer studies undertaken are the major differences in tissue localization of different contaminants in different marine organisms. This demonstrates the difficulty in generalizing about the behaviour of a class of contaminants in marine biota. Clearly, radiotracer methodologies offer great promise as a rapid and relatively inexpensive means for tracing contaminant behaviour and identifying target organs and tissues in specific marine species.

Field work at sea continued to focus on assessing carbon sequestration and removal from



the surface waters of the northwest Mediterranean Sea. Long term time-series studies now covering over a decade (1987–1999) have begun to bear fruit in revealing trends with frequencies greater than one year. Superimposed on an annual cycle, where high carbon exports occur in the winter–spring and low exports during the summer–autumn, there appears to be an inter-annual oscillation of about four years in the flux of carbon to depth. In addition, sporadic but intensive inputs of Saharan dust transported to the sea surface can act to increase carbon fluxes both by direct contribution of fine crustal particles and by increasing water column biological productivity (fertilization effects). These changes at different time-scales highlight the complex mechanisms involved in the production of particulate organic material in the surface ocean, the concomitant reduction of dissolved carbon dioxide gases, and the subsequent increase in the ocean's ability to take up atmospheric carbon dioxide.

In connection with these climate oriented studies, nuclear techniques were used in a field experiment to compare measurements of the downward flux of particles and carbon with computed estimates of particle removal from surface waters. During one month in the spring, three models of sediment traps commonly used by the international oceanographic community were deployed at sea, and the measured fluxes were compared with indirect estimates of carbon fluxes using the degree of disequilibria between thorium-234 and uranium-238. Results showed that records from all three models of traps were consistent with particle dynamics in the water column during the period sampled, and that carbon flux estimates based on the disequilibria of these natural radionuclides agreed quite well with direct in situ measurements.

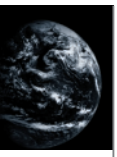
MONITORING AND STUDY OF MARINE POLLUTION

The use of carbon isotope techniques, coupled with gas chromatographic separation, to identify and assess the sources of organic materials such as carbon in the marine environment was further developed. Studies of the change in carbon-13 composition among lipid molecules synthesized by cultures of diverse photosyntetic organisms were also performed. Significant differences in the carbon isotope ratios were observed among the lipid molecules synthesized by the same organism and among homologues of the same lipid class. All these differences will be considered for the correct assignment of biomarker sources and for a better understanding of the biogeochemical processes in the environment.

The installation of a Finnigan Element high resolution inductively coupled mass spectrometer was completed in 1999. Sample preparation and analysis routines were refined to make full use of the low flow sample introduction options. The instrumental capabilities, notably high resolution and femtogram detection limits, have benefited several projects. Samples from the Aegean Sea and the Persian Gulf have been analysed for trace metals, rare earth elements and uranium isotopes.

New Experimental Aquaria at the Marine Environment Laboratory in Monaco

This year saw the startup and expansion of IAEA-MEL's new state-of-the-art experimental aquaria facilities, which are used for research and training in marine radioecology. These specially designed laboratories are outfitted with individual mesocosms ranging in size from 70 to 3000 litres. The controlled aquaria can be automatically regulated at various temperatures and salinities in order to closely simulate different marine ecosystems, ranging from estuarine to the open ocean. This has allowed the application of radiotracer and isotope methodologies to assess the transfer, behaviour and fate of radionuclides and toxic trace contaminants in critical marine environments (e.g. Mediterranean and Atlantic coastal zones, tropical coral reefs and temporate pelagic regions). Agency Fellows and other trainees from Member States have begun to make use of these facilities in order to evaluate the usefulness of a variety of marine organisms as 'bioindicator species' for different contaminants being measured in their respective national monitoring programmes. ■



One new reference material (IAEA-408, Estuarine Sediment) was produced and is now available to the international scientific community. It was certified for pollutants such as organochlorine pesticides, petroleum hydrocarbons and PCBs.

As part of the Agency's programme of assistance to pollution monitoring efforts by Member States surveys of contamination by petroleum hydrocarbons and toxic metals were carried out in the area the covered by the Regional Organization for the Protection of the Marine Environment (ROPME) in the Persian Gulf. In addition, intercomparison exercises for metallic and organic contaminants in sediments and biota using split sample techniques were undertaken with the national laboratories in the ROPME, Black Sea and Mediterranean regions.

DEVELOPMENT AND MANAGEMENT OF WATER RESOURCES

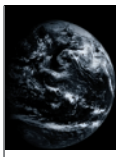
The tenth symposium on 'Isotope Techniques in Water Resources Development and Management' was held in Vienna in May. This symposium, organized by the Agency at four year intervals, was co-sponsored by UNESCO, WMO and the International Association of Hydrological Sciences (IAHS). Presentations were made on: isotope applications in surface water hydrology; groundwater resource management; climate change phenomena; and environmental management. The future research and development needs in isotope hydrology and the role of the Agency, both in support of research and applied work, were considered in a roundtable discussion.

Methodologies for the application of isotope techniques using fallout caesium-137 and lead-210 concentrations to assess soil erosion and sedimentation rates were improved in a CRP that was completed in 1999. It has been demonstrated that environmental radioactivity can be used to evaluate soil erosion, soil redistribution (sedimentation in lower areas or in flood plains) and the fraction of eroded soil which is transferred as sediment to surface water. The CRP succeeded in defining standardized methodology which will be made available as a handbook. In addition, reference inventories for the two radionuclides in different parts of the world were assembled, resulting in the identification of areas where soil concentrations were high enough to use the methodologies developed in this CRP. A description of the CRP and the results obtained were also presented at a meeting of the European Network for Research in Global Change (ENRICH), which uses caesium-137 and lead-210 for the establishment and calibration of global atmospheric circulation models.

"The results of a CRP on isotope techniques for the assessment of slow moving deep groundwater provide an additional tool for safety assessments of geological nuclear waste disposal sites."

The integration of isotope techniques with other hydrological and geochemical methods for evaluating the rate and history of groundwater recharge was further improved through a CRP on the isotope based assessment of the groundwater renewal rate in water scarce areas. Detailed isotopic and hydrogeochemical information was collected at 44 benchmark field sites, mainly located in arid regions. These data provided recharge rate estimates, verified through applied field research, ranging from fractions of a millimetre to tens of millimetres per annum. The methodology provides a unique approach to estimating the natural renewal rate of groundwater, which is difficult to assess in arid environments through conventional hydrological methods. The final report on this CRP will be published in 2000.

The final Research Co-ordination meeting for a CRP on isotope techniques for the assessment of slow moving deep groundwater and their potential application for the assessment of waste disposal sites was held in Vienna in August/September. The krypton-81 dating method was used in this CRP in the Great Artesian Basin of Australia to estimate groundwater ages in the range of several



thousands of years. This joint effort of seven institutes and the Agency is believed to have provided for the first time reliable information on groundwater age in this range. In addition, the results of the CRP provide an additional tool for safety assessments of geological nuclear waste disposal sites.

Emerging techniques for the determination of stable isotope ratios of light elements and their requirements in terms of reference materials were reviewed in an Advisory Group meeting on the state-of-the-art in gas chromatography/continuous flow isotope ratio mass spectrometry (GF-IRMS) and its applications in water resources and related environmental studies. In addition to isotope hydrology and geochemistry, the range of disciplines using isotope signatures has broadened significantly. As a consequence, the requirements of analytical instruments have changed drastically in some fields. Several new instrumental developments were discussed in the meeting with a focus on CF-IRMS and optical techniques for stable isotope determinations. The meeting defined the most urgent needs for internationally available stable isotope reference materials for organic substances and provided guidelines for setting priorities in the Agency's Stable Isotope Reference Materials Programme.

Final drafts of six volumes of teaching material covering the entire range of environmental isotope applications in hydrology were completed. To be published in 2000 in a UNESCO publication series entitled 'Technical Reports in Hydrology', this joint publication is aimed at participants in Agency training courses, as well as teaching institutes and universities worldwide.

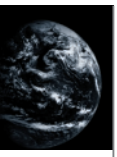
A scientific steering committee was constituted as prescribed in the recently signed Memorandum of Understanding between the Agency and WMO on the Global Network of Isotopes in Precipitation. The committee, which advises the two organizations on operational aspects of the network, held its first meeting in Vienna in July. The long term evolution of the network was discussed and specific measures for this purpose were defined at the meeting.

The development of software to facilitate the integration of isotopes in hydrology through a common database on hydrological studies and investigations conducted in Member States was completed. Named 'ISOHIS' (Isotope Hydrology Information System), this software is available on the Internet and is being distributed to national counterparts in Agency technical co-operation projects and to about 50 institutes.

An instruction manual for using isotopic and chemical techniques in geothermal reservoir development and management was completed. The manual provides the theoretical basis and procedures for using isotope techniques for geothermal reservoir exploration and management. It is expected to facilitate the development of trained personnel in Member States and improve the implementation of Agency technical co-operation projects in this field.

Analytical laboratories in Member States were assisted in the improvement of their procedures for chemical analysis through a series of intercomparison exercises. About 60 laboratories in Asia, the Middle East, Africa and Latin America participated in these exercises, which identified areas where improvements in procedures are needed to ensure acceptable chemical results. In one year, 47% of the laboratories have shown improvement in their laboratory performance.

Synergy with other international organizations was pursued through a consultative process for a new activity entitled 'International Programme for Isotopes in the Hydrological Cycle' in co-operation with WMO, UNESCO and scientific institutes in Member States. The goals of this initiative are to: fully integrate isotope hydrology in water sciences at universities; and establish, through the UNESCO/IHP (International Hydrological Programme), national committees hydrology to facilitate the application of isotope hydrology in the water and climate sectors of Member States. At a consultative meeting with UNESCO and WMO in December, it was decided to make a formal proposal to the UNESCO/IHP Inter-governmental Council meeting in 2000 for the formation of such



national committees within the framework of the IHP committees.

One of the Agency's missions is to provide reference materials for isotope analysis worldwide. To this end, the analytical precision and accuracy of work in the Isotope Hydrology Laboratory of the Agency's Laboratories was improved through the use of a new equilibration device for oxygen-18/hydrogen-2 stable isotope analysis of water. This device, constructed at much lower cost than a commercially available device, improves precision for both $\delta^{18}O$ and $\delta^{2}H$ analysis by about a factor of two compared with that possible from the commercial devices currently in use. In addition, use of twofold $\delta^{2}H$ analysis, using a standard procedure and a precise equilibration procedure for all water samples, further improved the reliability of isotopic results.

A new and reliable method to determine the isotopic composition of air moisture was developed. This method uses molecular sieves to adsorb moisture for laboratory analysis and obviates the need for a cooling agent for sample collection. One of the important applications of this method is in lake water balance studies in remote areas where a supply of liquid nitrogen or dry ice, necessary for conventional sampling methods, is not available. The new method will improve the implementation of future technical co-operation projects on lake dynamics.

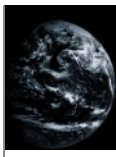
Two new analytical methods to analyse the carbon isotope composition of organic matter and the isotopic composition of oxygen gas were introduced in the Agency's Isotope Hydrology Laboratory. These procedures will improve quality assurance efforts for reference materials of organic substances, including re-evaluation of the isotopic properties of nine existing standards and the production of new organic, stable isotope reference materials suitable for advanced analytical techniques.

In order to ensure the ready availability of basic reference materials, attempts are being made to produce successor materials well ahead of the depletion of the available stock. Accordingly, a successor material for the primary reference material, VSMOW, was produced in a large quantity (300 litres). The isotopic composition of the new standard, VSMOW-1, is very nearly the same as the existing VSMOW standard, though production costs were a fraction of the currently estimated commercial price of about $1.2 million.

Two interlaboratory comparison exercises were conducted to strengthen the analytical precision and comparability of data produced in isotope hydrology laboratories around the world. The first focused on stable isotope composition in water samples. Ninety laboratories sent in results for four water samples shipped to them for analysis. The evaluation showed the need for such exercises, since a considerable fraction of laboratories reported data outside the acceptable range. Corrective action was taken by some of the laboratories to improve their analytical precision.

Isotope Techniques for the Mitigation of Arsenic Poisoning

Exposure to arsenic contaminated drinking water has affected millions of people in Bangladesh, resulting in a major public health crisis. The World Bank has initiated a $44 million project to address the mitigation of this serious problem. One of the options available is to exploit deep aquifers as alternative sources of drinking water. However, reliable criteria are not available to evaluate the long term consequences of this option. A new technical co-operation project was begun in 1999 to demonstrate the benefits of integrating isotope hydrology in arsenic mitigation efforts in Bangladesh. This project was formulated following initiatives taken by the United Nations Administrative Committee on Co-ordination, Subcommittee on Water Resources, where the Agency was designated as the lead organization for hydrogeology and geochemistry activities. The Agency's project has resulted in the development of isotopic criteria to assess the safety of deep groundwater, and has provided crucial information that was lacking in spite of substantial efforts that were expended in the use of non-nuclear technologies. ■



In Ethiopia, a new groundwater field is being developed to meet approximately 40% of the water demand of Addis Ababa, the capital city. At present, about 25 production wells have been prepared, but production has been delayed owing to the lack of an appropriate groundwater exploitation and management strategy. An Agency technical co-operation project is helping to integrate isotopic techniques for obtaining hydrological information that would assist in the development of an accurate exploitation and protection strategy for the well field. These efforts are complementary to those of other bilateral and multilateral donors who are also assisting the local water authority in water supply management.

"The ability to use isotope hydrology techniques for dam sustainability investigations is being developed through several technical co-operation projects."

Hydrological conditions of groundwater in multiple aquifers in the Tadla Plain, an economically important region in eastern Morocco, are being characterized through the use of isotope hydrology techniques under a technical co-operation project. This project is complementing the work of a UNDP/UNDESA-supported project for developing a model for water resources management in the Tadla Plain. Isotopic analysis of about 150 samples during 1999 provided crucial data for testing many of the assumptions previously made in the development of the hydrological model. Hydrology and isotope specialists from the water authority and the nuclear centre in Morocco participated in a workshop to review and interpret the data collected in the project.

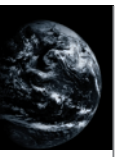
A new regional technical co-operation project on the sustainable development of groundwater resources was initiated. This project, involving seven countries in southern and eastern Africa, has the objective of facilitating the integration of isotope techniques with non-nuclear techniques for water resources development and management. Isotope techniques were also used in a technical co-operation project involving China, Costa Rica, El Salvador, Indonesia, Philippines and Thailand to monitor hydrological conditions in producing geothermal reservoirs, leading to lowered costs for electricity generation costs. In addition, the project in El Salvador developed the capacity to use geochemical techniques for predicting and controlling scale formation in the reservoir and increase its usable life for electricity generation.

Dam sustainability is an issue of great concern for many Member States. It is an issue that has different components. One of them is dam leakage, where the loss of water may endanger the stability of the dam itself or may be a waste of the natural resource. The second problem is related to reservoir siltation which, if not managed correctly, may drastically reduce the expected life of the dam. The ability to use isotope hydrology techniques for dam sustainability investigations is being developed through several technical co-operation projects, including one on dam leakage in Africa. Use of these methodologies is being extended to the Asia and Pacific area, incorporating the concepts included in the 'Thematic Plan on Dam Sustainability' that was developed this year.

A technical co-operation Model Project on groundwater resources in the Caracas Valley of Venezuela was completed with the final calibration of the mathematical model developed for the aquifer. The application of the model, which is based on isotopic data, showed that an increase of only 20% in the present pumping rates may exhaust the water in the aquifer in less than 15 years, much sooner than previously estimated. The use of this model is expected to improve the exploitation and management of this important urban aquifer.

INDUSTRIAL APPLICATIONS

Radiation processing is now emerging as an environmentally friendly technique for less chemical intensive processes and for making effluents free of pollutants. In recent years the use of ionizing radiation in the synthesis and modification of polymer based materials used



in the health care and plastics industries has also grown significantly.

The results and achievements of a recently completed CRP on irradiation treatment of water, wastewater and sludge demonstrated the advantages of using ionizing radiation to solve problems related to liquid wastes. A combination of treatment methodologies has been studied utilizing ionizing radiation and other agents for the decontamination of polluted water and wastewater. The technology has been taken up by the industry and engineering scale facilities are in operation.

In another recently completed CRP on the use of radiation processing to prepare biomaterials for applications in medicine, the advantages and unique properties of ionizing radiation in the preparation and modification of polymers for biomedical applications were demonstrated. Some of the typical applications achieved included: improvement of the sensitivity of microtitration plates for diagnostic purposes; stimuli-responsive radiation grafted coatings for on–off control devices; radiation synthesis of micro and nano particles for enzyme immobilization and drug delivery systems; preparation of hydrogels for wound dressings and drainage; and radiation synthesis of hydrogels for controlled drug delivery purposes and for contact media in ultrasonic applications.

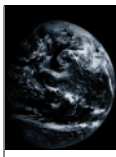
Improvement of the physical properties of radiation vulcanized natural rubber latex (RVNRL) was the subject of a CRP that was concluded in 1999. As a result of extensive research and development activities, RVNRL films with improved tensile strength, increased tear resistance and minimum residual protein were synthesized. The results have already been transferred to the relevant industries, and India, Malaysia and Thailand have started manufacturing products made from RVNRL. There are also indications that, especially for retrofit installation, the use of low energy self-shielded electron beam accelerators for the vulcanization of natural rubber latex will provide technical, environmental and economic advantages.

An expert meeting was held in Takasaki, Japan, on the radiation synthesis of 'intelligent' membranes, hydrogels and adsorbents. The present status and emerging applications

Electron Beam Technology for the Remediation of Water and Wastewater

Improvements in electron beam accelerator technology in recent years (e.g. increased power conversion efficiency and power output) and research in Member States have indicated that accelerators are suitable for the large scale treatment of polluted water. Pilot scale operations have also indicated that decontamination and disinfection of wastewater and drinking water are economically feasible. The results of R&D work carried out in a CRP on the irradiation treatment of water, wastewater and sludges have been successfully adapted by a number of Member States. Typical examples of large scale operations are the following:

- Groundwater containing chlorinated organic compounds in Lower Austria was treated using electron beam radiation in conjunction with ozone addition. Complete demineralization of pollutants has been achieved and all toxicity tests on treated water have proved negative.
- The city of Voronezh, in the Russian Federation, used ionizing radiation to treat groundwater which contained a detergent from an industrial process.
- A mobile electron beam accelerator developed in the USA has been used to demonstrate treatment of all forms of aqueous wastes. Highly contaminated groundwater in Germany and groundwater contaminated with a petroleum additive in the USA have been successfully treated with this mobile system.
- Effluents from a large chemical company in Brazil have been treated on a pilot scale with electron beams.
- A pilot plant constructed in a textile dye wastewater plant in the Republic of Korea has proved successful in treating effluents. ■



of ion track membranes, these products, analysed and evaluated, especially in relation to their use in separation processes.

Another expert meeting in Vienna examined the technical and economic aspects of the radiation treatment of wastewater. Studies have indicated that electron beam accelerators are most suited for large quantities of water and wastewater and, because of the required redundancy in any environmental application, several small size accelerators can be utilized instead of a single large power installation. On the basis of past experience with pilot and full scale systems, the typical costs for the electron beam treatment of wastewater were found to compare favourably with other advanced water treatment systems.

"The typical costs for the electron beam treatment of wastewater were found to compare favourably with other advanced water treatment systems."

A two year regional technical co-operation project in Europe was initiated with the long term objective of transferring radiation technology for the treatment of industrial and municipal wastewater. In the short term, the goal is to increase the awareness and induce wider acceptance of the advantages of using radiation in the treatment of liquid wastes.

The services of consultants were sought to evaluate the status and trends in software development for tracer studies. Residence time distribution software for troubleshooting and process analysis was recommended as the standard for more than 30 Member State tracer groups. This software facilitates the extraction of information on the process, helps its optimization and improves the quality of services to end users.

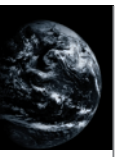
Radiotracer and nucleonic gauge technologies continue to be an active component of national and regional technical co-operation projects, in particular in the RCA and ARCAL regions. To stimulate training efforts, a number of regional activities on radiotracers, sealed sources and nucleonic gauges applications in the petroleum and petrochemical industries were conducted. The major techniques included: residence time distribution analysis for troubleshooting; radiotracers for accurate flow rate calibration and leak detection; tracers for enhancing oil recovery; gamma and neutron scanning techniques for the inspection of columns and tanks in oil refineries; the thin layer activation technique as applied to the monitoring of wear and corrosion; and a cross-correlation technique for multiphase flow rate measurement.

A guidebook on radiotracer and sealed source technology as applied to industry was prepared and practical manuals of procedures, norms and quality control in tracing and gauging work were compiled. These documents will facilitate the transfer of technology and help in the accreditation of tracing and gauging groups in developing countries.

A technical co-operation Model Project on radiotracer applications for enhancing oil recovery was started in China in January. The methodology for interwell communication and residual oil evaluation using a multi-tracer technique was completed and tested at the Dagang Oil Field. A new radiotracer compound was prepared, tested and validated for large scale applications in 30 operating oil fields, with an increase in oil recovery of about 10% being reported.

An Advisory Group meeting was held in December to identify priority problem areas in industry in the Asia–Pacific region, and to formulate project proposals for the Agency in 2001 and 2002. The meeting identified four priority industrial sectors for which project proposals were formulated:

- Process diagnostics and optimization in the petroleum/chemical industry using non-destructive testing (NDT), radiotracers and sealed sources;
- Optimization of mineral resources recovery by using low radioactivity and portable nucleonic gauges;
- Modification of natural polymers through radiation processing;

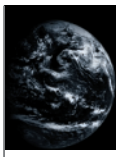


- Demonstration facilities for the disposal of hospital waste and the treatment of industrial wastewater using radiation.

The expected benefit to Member States in the RCA region will be the establishment of advanced and intrinsically safe nuclear technologies for problem solving.

Encouraged by results in other regions, a project on NDT in industry has been started in the West Asia region. The objectives of the project are to establish and upgrade NDT groups to exploit the potential of this technology in the industrial and civil engineering sectors and to initiate a process for the training and certification of NDT personnel. The main emphasis has been to educate, train and certify a core group of persons in each Member State in order to fulfil the requirements of international standards, such as ISO-9712. These people can then continue the training and certification process in their countries, ultimately developing local NDT capabilities for the quality control of industrial products.

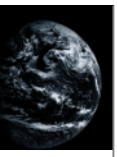
Five Advisory Group meetings were organized on the topics that are considered to be of the most importance for the establishment of NDT technology in Member States. Concrete structures such as buildings, bridges, roads, runways, pavements, retaining walls, dams, sewage lines, tunnels, storage tanks and specialized buildings such as nuclear reactor containments structures, comprise a vast field for the application of NDT. To be able to successfully introduce this technology in developing Member States, it is important to educate, train and certify a large number of people in this field in view of the number of concrete structures requiring inspection and testing. At two of these meetings, guidebooks on concrete structure NDT and on the fabrication of NDT test pieces were completed. The other three meetings defined the syllabus and compiled university examination questions on NDT. In addition, two text books were published, one a guidebook on NDT for industrial management and quality control personnel, and the other on the ultrasonic testing of materials.



PHYSICAL AND CHEMICAL SCIENCES

PROGRAMME OBJECTIVE

To promote research and development in specific applications of nuclear, physical and chemical sciences for solving practical problems in the fields of energy, environment, nuclear medicine, material sciences and industry; and to enhance the utilization of existing research reactors and accelerators and help national analytical laboratories in acquiring skills in international quality in their analytical measurements.



OVERVIEW

A significant outcome of the Agency's activities in the physical and chemical sciences programme was the preparation of the first international library on photonuclear data, which has important medical and shielding applications. A charged particle reaction data library for medical cyclotrons was also completed. Scientists in Member States continued to make increasing use of the nuclear data centre of the Agency. A new software package was produced for gamma ray spectrometry and distributed to many Member States. Work on nuclear technologies for humanitarian demining was initiated. Training in nuclear instrumentation continued to be provided to developing Member States. The research reactor database was made available on the Internet. New technetium-99m based radiopharmaceuticals for tumour imaging were developed. Emphasis was also placed on good manufacturing practices and quality assurance (QA) methodology in making radiopharmaceuticals. In radioanalytical analysis, there was increasing emphasis on introducing quality control and QA procedures in Member State laboratories. In the area of nuclear fusion, the Agency assisted in the formulation of a revised Memorandum of Understanding between the European Union, the Russian Federation and Japan on work related to the International Thermonuclear Experimental Reactor (ITER) project.

NUCLEAR AND ATOMIC DATA FOR APPLICATIONS

Use of the Agency's nuclear data services by scientists in Member States showed steady growth. As shown in the table below, the number of individual data retrievals via the Internet (*http://www-nds.iaea.or.at*) from the continuously updated main nuclear databases (containing compiled experimental nuclear data and evaluated data libraries from national projects) increased by more than 30% in 1999. Telnet based retrievals, after a decrease in 1998 owing to rising competition from more user friendly Web interface, stabilized at a level of about 2000 retrievals per year, indicating that Telnet based interactive data retrieval tools are still preferred by a number of users, most likely those with low capacity Internet connections.

The Agency has developed the capability to produce and distribute CD-ROM versions of all of its main nuclear data databases. Through the use of this medium, users not connected to the Internet can avail themselves of fast desktop access to the same data available from the nuclear data server at the time that the CD-ROM was produced. In addition, the CD-ROM is the medium preferred by scientists working with large data libraries with relatively static content. A good example is the very large FENDL-2 library. As shown in the table below, the number of CD-ROMs distributed in response to individual data requests doubled in 1999.

The number of off-line retrievals, which include mainly responses to requests for printed material, increased by 15% in 1999. In an attempt to contain costs, about 50% of all reports in the INDC(NDS) series have been made available on the Internet. More than 1200 such reports were downloaded by users in 1999. Informal reports, containing short summary descriptions of the available services, databases and data processing codes, have also been made available on the Internet.

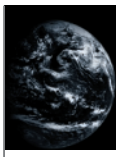
As a result of co-operation with other nuclear data centres, a new reactor dosimetry file, 'RRDF-98', and a library of evaluated cross-sections of nuclear interactions between light charged particles were made available to users. This file can be used to 'unfold' the spectra of neutrons incident on a reactor pressure vessel (RPV) to deduce neutron induced lattice displacements. Such information is important for the assessment of the lifetime of the RPV. The library can also be used in fusion and astrophysical applications.

A new computer package, 'ZVView', designed for interactive graphical display of nuclear reaction cross-sections retrieved from Agency experimental and evaluated nuclear databases, was made available. Also, a new program was developed to facilitate the display of statistical information concerning Internet access to Agency services, broken down, for example, by data topic or geographical region. This provides valuable feedback on the evolving requirements of data users.

A CRP on the compilation and evaluation of photonuclear data for applications was completed, with the final Research Co-ordination meeting held in Tokyo in October. The project produced the first international library of photonuclear data, with information on 164 isotopes of importance for medical,

Dissemination of Nuclear Data

	1995	1996	1997	1998	1999
Retrievals from main Internet nuclear databases	—	—	40	6830	8970
Telnet based nuclear data retrievals	4400	5700	7350	2700	2180
Information on CD-ROMS	—	—	—	205	420
Off-line retrievals	1550	800	1900	1995	2290



shielding and other applications in a format suitable for transport calculations.

A new CRP on the development of a database for prompt gamma ray neutron activation analysis was initiated. The database, to be developed in both electronic and printed forms, will include the most recent data on 80 elements, such as capture gamma ray energies, intensities, k_0 factors and neutron cross-sections, and will extend the capabilities of this powerful analytical technique. Because the technique does not rely on the creation of a long lived activation product, it is useful for imaging practically any element, including important light elements such as hydrogen and carbon, in applications such as materials science, food analysis, medicine and the environment.

A charged particle cross-section database for medical radioisotope production was completed. The database includes 26 reactions for the most important diagnostic radioisotopes and 22 beam monitor reactions which are of importance for users of more than 200 medical cyclotrons.

Support was provided to two technical co-operation projects whose goal was to enhance regional use of Agency and local nuclear data services. The first was a regional project to establish a mirror site of the Agency's on-line nuclear data services in São Paulo, Brazil, to serve users in Latin American and Caribbean countries. In addition to providing improved services, the mirror server will be used as a training facility for future technical co-operation workshops and courses. The other project concerned greater utilization of the Ghana research reactor, with the focus on creating a local area network to provide nuclear data services at the reactor facility.

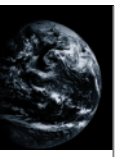
A major numerical database for atomic and molecular data applications was completed for electron impact processes on excited hydrogen molecules and their isotopes. Collision processes in these systems play an important role in the kinetics of low temperature plasmas. In collaboration with the FOM-Institute for Atomic and Molecular Physics in Amsterdam, a new, critically assessed atomic database for the electron impact excitation of helium atoms was completed. These data will be used by fusion plasma modellers and reactor engineers and will also be used for diagnostic studies in low temperature plasmas.

NUCLEAR INSTRUMENTATION

The final Research Co-ordination meeting for a CRP on software utilities for gamma ray spectrometry was held in October. The CRP dealt with the basic applications of nuclear data handling and with new PC computer codes and libraries for gamma ray spectrometry. As a

Reference Input Parameter Library for Nuclear Reaction Modelling

Evaluators of nuclear data in Member States make substantial use of nuclear physics calculations in order to correctly interpolate between available measurements and to ensure that the final recommended values satisfy physics requirements, such as conservation of energy. The main theoretical methods used in evaluating nuclear reaction data below 100 MeV are based on optical and statistical models. Such calculations must be supplied with a large number of input 'parameters', inferred from extensive comparisons of theoretical predictions with data measurements. In an effort to formalize this process of parameter selection, and thereby improve the quality and consistency of nuclear data evaluations, a CRP was conducted to develop a Reference Input Parameter Library (RIPL). The primary output of this CRP is the 'RIPL Starter File', describing nuclear reactions due to incident neutrons, protons and gamma rays, as well as hydrogen–2, –3, and helium–3 and –4 nuclei. RIPL is documented in an Agency technical document (IAEA-TECDOC-1034), which contains a full description of the library and includes the basis of the parameter selection. The topics covered include: atomic masses and deformations; discrete level schemes; average neutron resonance parameters; optical model parameters; level densities; gamma ray strength functions; and continuum angular distributions. ■



result of this CRP, new software packages were developed for: measurements involving low level sodium iodide spectra; gamma ray spectra from high purity germanium detectors; Doppler broadened annihilation peaks; gamma ray libraries; true coincidence corrections; efficiency calculation for large sources; and library driven analysis of gamma ray spectra. These new computer codes will help Member States make more accurate measurements of materials constituents in many fields, such as physics, chemistry, life sciences, industry, archaeology and environmental monitoring.

A new CRP on the application of nuclear techniques to anti-personnel land mines was initiated in 1999. The first Research Co-ordination meeting was held in Zagreb, Croatia. The meeting emphasized the potential of nuclear based methods for the identification of land mines and pointed out the possibility of combining nuclear sensors with other methods for the localization of such buried objects.

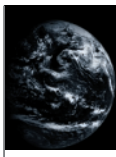
Work at the Agency's Laboratories at Seibersdorf included:

- Establishment of training facilities for the design and repair of electronic modules based on surface mounted technology (SMT);
- Development of educational kits for training in nuclear electronics, including SMT and photovoltaic kits (based on solar energy) for instruments with switch mode power supplies;
- Development and testing of an original scanning system (including hardware and software) for large volume cadium–zinc–telluride detectors applied to portable gamma spectrometry;
- Construction of miniature power supplies for in-field gamma spectrometry applications and improvements to hardware and software for a new generation of hand held radiation monitors;
- Development and implementation of a Windows 95/NT software package for a total reflection X ray fluorescence (XRF) module;
- Adaptation for practical application of optimum XRF sample preparation procedures, and training provided in parts per billion concentration measurements of iodide and arsenic in water samples.

UTILIZATION OF RESEARCH REACTORS AND LOW ENERGY ACCELERATORS

With 60% of all research reactors in the world being 30 years or older, the issue of ageing is of increasing concern. To address this and other related subjects, the Agency held an international symposium on research reactor utilization, safety and management near Lisbon in September. Age induced problems such as corrosion, irradiation damage effects and reduced component reliability were identified as key areas requiring active in-service inspection programmes. In addition, the importance of proper documentation and advance planning for decommissioning was stressed for ageing reactors. The symposium also highlighted the fact that more new research reactors are now being planned, designed and built than at any time in the recent past, with most being of higher power (i.e. approximately 20 MW). In a changing environment, many of these facilities need to develop a strategic plan, with input from all concerned, in order to remain viable. Another issue of concern in the research reactor community is the handling of spent fuel, particularly in light of the planned cessation by the USA of its fuel repatriation programme by mid-2006. In practice, this may force many otherwise productive research reactors to close down because of the lack of any suitable alternative fuel disposal options. It was emphasized that for many research reactors, only the eventual implementation of regional or international facilities for the interim storage and eventual disposal of spent fuel would permit their continued operation.

"A new CRP emphasized the potential of nuclear based methods for the identification of land mines."



At a Technical Committee meeting in Debrecen, Hungary, in October, on the applications of accelerator based neutron sources, the recent development of small portable 'sealed tube' electrostatic neutron generators was reviewed. The potential of these types of sources in fields such as humanitarian demining, elemental analysis and industry was emphasized. In many cases a neutron source of a sealed tube or inertial electrostatic confinement type could replace an isotopic neutron source, thereby minimizing the risk of radioactive contamination of the environment.

A Technical Committee meeting was held in June in Vienna on current issues in neutron capture therapy (NCT). This was a timely meeting since some operators of research reactors are considering involvement in this area. The meeting highlighted the fact that this is still an unproven therapy, and that there is little need for more facilities to spend the large amounts of money necessary to set up NCT clinical trials.

Work in support of technical co-operation activities included monitoring of projects dealing with the utilization of research reactors and accelerators, and assistance to neutron beam utilization projects and to projects related to new reactors. A significant outcome from one research reactor project was the development of a neutron diffraction beam in Greece, which will be used in research work sponsored by the European Union.

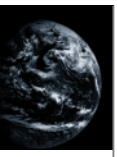
RADIOCHEMICAL APPLICATIONS

At an international seminar on therapeutic applications of radiopharmaceuticals, organized in Hyderabad, India, in January, current developments and future trends of this promising nuclear medicine modality were reviewed. In particular, the use of beta and alpha particle radionuclide emitters tagged to biomolecule carriers, such as monoclonal antibodies and peptides, was emphasized.

The current status of and future trends in target and processing technologies for cyclotron production of medically important radionuclides were reviewed using the services of consultants. Recognizing the needs of developing countries which have established cyclotron centres for radionuclide production, it was concluded that further development and research were required to improve solid target preparation techniques. This in turn would contribute to better utilization of cyclotron facilities and greater availability of important radionuclides such as palladium-103, which has become an extremely important radionuclide for the treatment of prostate cancer when incorporated into sealed sources.

Technetium-99m Labelled Peptides for Tumour Imaging

The introduction of indium-111–octreotide for imaging neuro-endocrine tumours marked a new turn in radiopharmaceutical development, opening up the vast potential of peptide based agents for diagnosis and therapy. However, indium-111–octreotide is not ideal for imaging studies and is also expensive and not available in countries that do not have cyclotrons. The availability of technetium-99m–octreotide will make this technique available in almost all countries at an affordable cost. Developing such an agent based on the octreotide analogue was the aim of a CRP which was concluded in 1999. The results of work carried out in laboratories in Europe, Asia and Latin America resulted in the development of a promising technetium-99m complex, which exhibits similar properties to indium-111–octreotide in laboratory studies. This compound has shown comparable if not better images in preliminary studies in patients. The work carried out in this CRP has paved the way for the use of technetium-99m–octreotide analogues and extended the benefits of the imaging procedure to all parts of the world. The CRP also helped many participants from developing countries acquire expertise in current interdisciplinary areas of radiopharmaceutical R&D, including peptide conjugation and purification, technetium-99m labelling of the conjugate, HPLC techniques for purification and radiochemical analysis, in vitro receptor binding and ligand displacement assays and animal biodistribution studies. ■



A significant milestone was the inauguration in November of a cyclotron–PET centre in Prague, the first of its kind in Eastern Europe. Developed as part of an Agency technical co-operation project, this centre features dedicated radiochemical facilities for the production of a metabolic tracer widely used in cardiology and oncology. It is planned to produce and distribute this tracer to hospitals in the Czech Republic.

Analytical data for the certification of two algae reference materials (IAEA-392 and IAEA-413) were reviewed. The results indicate that the certification exercise was a success and that both materials can be certified for approximately 20 elements.

Work in the field of chemistry at the Agency's Laboratories at Seibersdorf included: a quality system following the guidelines of ISO-17025; assistance to laboratories in Member States in Eastern Europe to establish and/or improve their level of quality assurance through the establishment of a quality system; participation in a workshop for auditors and preparation of proficiency test material to evaluate the performance of these laboratories.

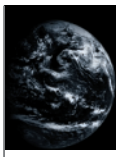
PLASMA PHYSICS APPLICATIONS AND CONTROLLED FUSION RESEARCH

Controlled fusion research activities are carried out in around 50 Agency Member States to develop a new energy source using the nuclear fusion reactions that power the sun and the stars. To promote international collaboration that will be of benefit to a significant number of Member States in selected areas of plasma physics and controlled fusion research and development, the Agency provides assistance through a variety of activities such as the convening of conferences, technical meetings and CRPs. These activities: facilitate the exchange of technical information; foster co-operation between major laboratories and developing Member States; promote spin-off applications; help developing Member States strengthen their research programmes; and provide support for the ITER Engineering Design Activities.

A Technical Committee meeting on first principle based transport theory, held in Kloster Seeon, Germany, in June, provided a forum for discussion of a wide range of plasma physics theories that aim to predict the rate of heat loss ('transport') from a magnetically confined thermonuclear plasma. Three dimensional computer simulations of plasma particle motion using millions of grid points show the occurrence of plasma 'streamers' or 'zonal flows' that cross the magnetic field, causing rapid local heat flows. The plasma theory is now able to predict the conditions under which 'internal transport barriers' reduce the plasma heat loss rate, resulting in better operation. A summary of the meeting is being published in the Agency's *Nuclear Fusion* journal.

Another Technical Committee meeting on electron cyclotron resonance heating (ECRH) physics and technology for fusion devices was held in Oarai, Japan, in October. ECRH may be used in the future to reduce tearing modes, to suppress sawtooth oscillations, and to help sustain internal transport barriers in tokamaks. After microwave heat pulses are injected into a plasma, the thermal diffusivity can be calculated from the rate at which the heat pulse spreads. Several laboratories are working to develop gyrotrons that can generate about 1 MW steady state with good efficiency (i.e. >30%). Diamond windows are being developed because their low microwave absorption and high thermal conductivity permit them to transmit much higher power than ordinary windows without cracking.

Control, data acquisition and remote participation for fusion research formed the subject of a Technical Committee meeting held in Lisbon in June. A large variety of plasma and machine control systems as well as remote handling systems were presented from many experiments. In addition, reports were presented on new Internet based user interfaces providing complete read/write access to entry tables for authorized users via common browsers. There was consensus that unification of the different systems was needed to facilitate remote collaboration in



fusion research, because all major experiments in operation and those currently under construction support multiple groups interactively participating in ongoing experiments from off-site locations.

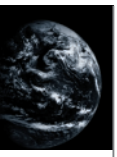
H-mode (high confinement) physics/transport barriers in magnetically confined fusion plasmas were studied in a Technical Committee meeting held in Oxford, United Kingdom, in September. Results indicated improved confinement and stability performance with internal and edge transport barriers in various devices in long pulse discharges with reversed magnetic shear through a large number of control schemes. The transport barrier which exists at the plasma edge in high confinement regimes is now recognized to be as important as the global energy confinement. The goal for the near future is to reproduce favourable 'small' edge localized mode regimes in several experimental devices with different plasma sizes and parameters before the extrapolation to ITER is implemented. High density *H*-mode operation with high field side pellet refuelling allows both good *H*-mode confinement and high plasma density near the empirical Greenwald density limit. Such operation could provide significant advantages for a fusion reactor.

"Key results achieved in environmental applications of plasma assisted discharges included the development and field testing of a prototype plasma pyrolysis system for the treatment of medical wastes."

Energetic particles in magnetic confinement systems were discussed at a Technical Committee meeting in Naka, Japan, in October. The status of runaway electrons produced during disruptions in tokamak plasmas has changed from being an innocuous phenomenon, mainly used to probe magnetic turbulence, to a serious threat to the first wall of future large tokamaks. Reliable avoidance schemes need to be validated for application to ITER. Present theoretical investigations will contribute to the development of the neoclassical theory of fast ions; a non-linear kinetic fluid model was developed that includes kinetic effects of all particle species in high beta plasmas. Several questions still have to be resolved experimentally and theoretically. One concerns runaway electrons: how many electrons will be accelerated, how are they confined, and what can be expected for the electron impact to the first wall of tokamaks. The second question is on fast ions. Many aspects of fast ion behaviour in tokamaks are well understood, but their confinement properties in stellarators need further clarification, as does the role of kinetic and non-linear Alfvén instabilities in magnetic confinement systems.

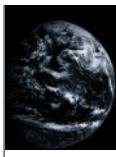
A finding at a Technical Committee meeting on research using small fusion devices, held in October in Chengdu, China, was that improved machine and diagnostic performance of the HL-1M tokamak resulted in improved confinement and reproducibility of the plasma discharges; the diagnostic systems were also improved. Another finding was that supersonic and helium molecular beam injection experiments showed promising results, and gas doping for impurity transport studies seemed to play an important role for the understanding of the control mechanisms of fusion plasmas. Magnetohydrodynamic studies using Mirnov coils and heavy ion beam probes of the plasma edge were also reported. Measurements with Mirnov coils showed that magnetic turbulences are composed of two components: broadband fluctuations caused by microinstabilities and coherent modes, the latter associated with the rotation of an $m = 2$ magnetic island within the plasma column. A new phenomenon was observed in the single trajectory of an injected heavy ion beam: the sample volume — the area of secondary ionization allowing plasma potential measurements — was split up into two volumes.

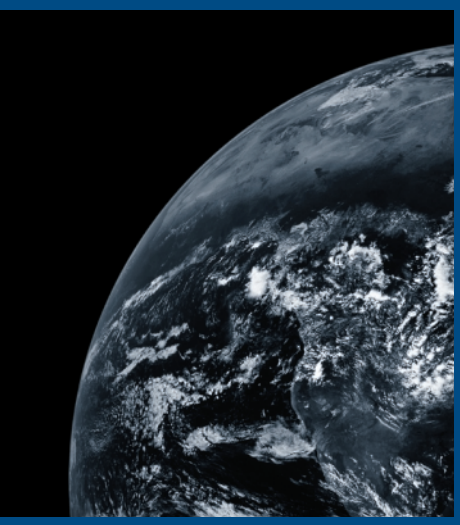
A Technical Committee meeting on steady state operation of magnetic fusion devices was held in Fukuoka, Japan, in October. The topics included: long pulse tokamak and stellarator discharges andadvanced configurations;



required technologies for long pulse operation of magnetic fusion devices; plasma facing components; heating and current drive scenarios; control systems, diagnostics for long pulse operation; theory; and modelling. Reports were presented on several new devices currently under construction that will have pulse lengths from 300 to 1000 seconds and plasma currents of 1 to 2 MA, similar to the planned pulse length of the ITER tokamak. Results from the TRIAM-1M tokamak show a regime of enhanced confinement and current drive efficiency by careful tuning of the heating power. The results achieved at the Large Helical Device show steadily increasing performance, with pulse lengths of up to 35 seconds at high power. There were also reports on a comprehensive model developed for transport and electron current drive that is able to describe low confinement modes and reduced transport for low/reversed shear and high poloidal beta required for internal transport control, a key issue for plasma control in ITER. A summary of the meeting and selected papers will be published in the *Nuclear Fusion* journal.

The final Research Co-ordination meeting for a CRP on engineering, industrial and environmental applications of plasma physics and fusion technologies was held in November in Vienna. Among the topics addressed were: plasma assisted surface engineering for enhanced surface properties in laboratory and industry; application of plasma technologies for the processing of hazardous wastes in gaseous, liquid and solid forms; interaction between low temperature plasma and fusion technology; and basic physics studies on these topics. One result of the CRP was greater inter-laboratory collaboration and opportunities for the training of students from developing countries. Key results achieved in environmental applications of plasma assisted discharges included: the development and field testing of a prototype plasma pyrolysis system for the treatment of medical wastes; and the construction of a silent dielectric barrier discharge device as a cheap ozone gas generator. The latter system has been tested in treating sewage water from biological organisms, cleaning coal from sulphur compounds and removing water vapour from the natural gas that accompanies oil.





The Agency's Programme in 1999: Safety

NUCLEAR SAFETY

PROGRAMME OBJECTIVE

To assist in achieving and maintaining a high level of safety of nuclear installations operating worldwide through international harmonization of safety standards and norms and the provision of advice and services.

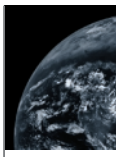
OVERVIEW

Activities in this area concentrated on supporting intergovernmental efforts to strengthen nuclear safety around the world. The focus was on developing common safety standards, providing a variety of expert services, fostering the exchange of information on safety issues and supporting co-ordinated research in Member States. The development of nuclear safety standards focused on their review, revision and elaboration in the areas of legal and governmental infrastructure, and siting, design and operation of nuclear power plants and research reactors. The development of operational safety review services placed greater emphasis on the management of safety, safety culture and self-assessment.

NUCLEAR POWER PLANT SAFETY ASSESSMENT

Two Safety Reports were completed, one on implementation of accident management programmes and the other on accident analysis of nuclear power plants. The former focuses on the contribution of accident management to defence in depth. The report on accident analysis presents examples of good practices for performing deterministic safety analyses of nuclear power plants and discusses the requirements for maintaining an adequate level of quality of the safety analyses.

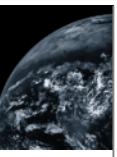
Recent work on safety indicators has focused on the development of a framework for the establishment of operational safety performance indicator programmes at nuclear power plants. This began with a definition of the concept of operational safety performance and the identification of 'operational safety attributes'. A hierarchical structure of 'overall', 'strategic' and



'specific' indicators was developed. Pilot plant studies conducted over a 15 month period have indicated that the proposed framework provides a good basis for the development of a plant specific tool for self-assessment. These results provided the basis for a new CRP on safety indicators.

The Agency's work in the area of probabilistic safety analysis (PSA) concentrated on establishing priorities for its application, and improving the quality and consistency of PSAs to support such applications. Two technical documents, on quality assurance for PSAs and on 'living' PSAs, were published. In co-operation with the OECD/NEA, guidance was developed to encourage more thorough regulatory review of PSAs. In addition to this developmental work, peer review and expert advice services were provided. International Peer Review Service (IPERS) missions reviewed the shutdown and low power PSAs for the Paks nuclear power plant in Hungary and the Bohunice V2 plant in Slovakia. Expert reviews were performed for the KANUPP PSA in Pakistan, and the Kozloduy nuclear power plant PSA, which were limited to internal events and fire and seismic analyses.

"The Extrabudgetary Programme on the Safety of Nuclear Installations in South East Asia, Pacific and Far East Countries placed particular emphasis on enhancing the technical capabilities of regulatory bodies and technical support organizations."



DESIGN AND ENGINEERING SAFETY

The updating of the safety standards for nuclear power plant siting and design currently represents a substantial part of work in this area. Publications were issued on: root cause analysis for fire events; implementation and review of ageing management; assessment and management of major nuclear power plants components important to safety; and a simplified approach to estimating reference source term for LWR design. In addition, guidelines for the Agency's Design Safety Review Services and for Ageing Management Assessment Teams were issued.

Engineering Safety Review Services in the form of technical co-operation missions and workshops were organized in 20 Member States (see Annex, Table A5). Design Safety Review Service missions (including safety aspects of configuration management and of ageing management) visited the Islamic Republic of Iran, Pakistan, Romania and Ukraine.

Seismic evaluations of existing nuclear power plants account for the majority of missions on internal/external events. These missions aim to provide plants with feedback of experience from other countries and thereby harmonize international practices and optimize the use of resources. Fire safety is also a key issue in operational safety to which increasing attention is being paid in periodic safety reviews. Accordingly, two fire safety missions were conducted, one to Pakistan and the other to China, and recommendations were made to improve compliance with the Agency's safety standards. A number of technical co-operation missions were made to the Islamic Republic of Iran relating to the WWER-1000 reactor being constructed at Bushehr. These included reviews of the seismic hazard, foundation safety, the primary circuit and the provision of guidance to improve the preliminary safety analysis report.

A new extrabudgetary programme was established in 1999 to co-ordinate and assist with actions relating to intergranular stress corrosion cracking in stainless steel piping at RBMK reactors. The programme will focus on: improving in-service inspection and qualification; comprehensive assessments; qualification of repair techniques; and decontamination methods.

The Extrabudgetary Programme on the Safety of Nuclear Installations in South East Asia, Pacific and Far East Countries continued to provide assistance to Member States in the

region, placing particular emphasis on enhancing the technical capabilities of regulatory bodies and technical support organizations. Activities in 1999 included: a regional training course on research reactor safety; a review of the Malaysian regulatory organization, pre-IRRT (International Regulatory Review Team) missions to Indonesia and Viet Nam and a workshop on the regulatory function in Thailand; four design safety missions, a safety review of an experimental fast reactor and two PSA workshops in China; and an expert mission to Indonesia on emergency preparedness.

OPERATIONAL SAFETY

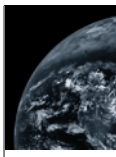
Four Operational Safety Review Team (OSART) missions were conducted during 1999, along with four preparatory visits for missions in 2000 and four follow-up visits (see Annex, Table A7). The missions identified opportunities for the improvement of operational safety in a number of areas, including safety management (establishing and communicating management expectations for safety performance), surveillance and preventive maintenance, facility condition and housekeeping, human performance, radiological protection, plant procedures and quality assurance. The OSMIR database of OSART mission results, which contains the results from all missions and follow-ups since 1991, was made available to utilities in Member States on CD-ROM.

The provision of technical assistance and advice is being increasingly linked to OSART reviews. As part of post-OSART assistance to encourage the self-assessment of operational safety, three seminars on OSART methodology were conducted in France. Technical assistance missions after the pre-OSART visit to CHASNUPP were organized at the request of the authorities in Pakistan to help the staff of the operating organization and the regulatory body to focus on operational safety matters as the plant shifts from construction to commissioning and startup.

A new operational safety service — Peer Review of Operational Safety Performance Experience (PROSPER) — was launched. The PROSPER service expands the scope of the Assessment of Safety Significant Events Team (ASSET) services to include the capability of a plant to make effective use of all operational performance data to enhance its safety performance. The review of significant event analysis information will continue to be a cornerstone of the service, but the use of information on operational data, such as low level events and near misses, and of external operational experience, to reduce failures will also be reviewed, and additional emphasis will be placed on the appropriateness, timeliness and effectiveness of corrective actions.

The Agency's operational safety services are being enhanced to better meet current challenges — increased competition, social and political changes and economic transition — and future needs identified by the Member States which use the services. An Advisory Group meeting in December endorsed the Agency's initiatives in this respect, and made a number of recommendations. In the management of safety culture, services should include an enhanced capability for the review of and assistance with management effectiveness in developing and maintaining a strong safety culture in the face of organizational and economic pressures. More emphasis should be placed in all services on the measures necessary to compensate for an ageing and shrinking nuclear work force and the loss of institutional memory. In the area of safety improvements and modernization, more guidance and services are required to assist Member States in decisions involving: modernization and improvement of safety related hardware and software; procedures; application of new safety standards; use of risk based decision making process; and new and more sophisticated safety performance indicators. Efforts in this area must also take into account possible overlap of activities with other organizations.

One element of this enhancement has been to improve the integration and co-ordination of the OSART, ASSET and the Safety Culture Enhancement services by conducting missions and training activities with mixed teams (e.g. an ASSET team leader leading an OSART



mission). This approach has now been extended to include other safety review services such as IRRT and the Integrated Safety Assessment of Research Reactors (INSARR) services. Co-ordination and communication has also been improved with other international organizations providing operational safety services to nuclear power plants.

The Agency's operational safety review services are increasingly focusing on helping utilities improve their management of safety and safety culture, and promoting self-assessment as a way of sustaining good safety performance. A series of technical co-operation missions was carried out to assist Electronuclear, the operators of the Angra nuclear power plant in Brazil, to train staff in the self-assessment of safety culture. Assistance will be continued as Electronuclear implements the recommended improvements, and it is intended that the whole process will also serve as a model for offering a comprehensive and integrated programme of assistance to other Member States.

"Member States have requested the Agency to develop overview processes for corporate and nuclear installation management."

Initiatives continued for the evaluation of utility self-assessment activities to gauge their effectiveness in improving operational safety performance, and on how these activities should be incorporated into operational safety services. Reflecting the strong interest by nuclear industry and governmental organizations, the Agency issued a guidance document on the self-assessment of operational safety for nuclear power plants to assist organizations in providing a stronger focus on operational safety.

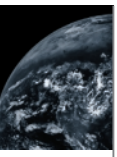
In the area of safety management, Member States have requested the Agency to develop overview processes for corporate and nuclear installation management. These enhancements, including the development of guidelines, assessment services, workshops and self-assessment tools, will be integrated into the OSART–ASSET–Safety Culture services. To support this initiative, a Technical Committee meeting in Canada provided a broad exchange of corporate level and senior regulatory practices and experience in safety management and safety culture.

RESEARCH REACTOR SAFETY

INSARR missions to Finland and Belgium indicated increased interest in this service in western and northern Europe, and seven safety missions were carried out to research reactors in Belarus, Bulgaria, Poland, the Russian Federation and Ukraine, under European regional technical co-operation projects. Other safety missions visited Nigeria — where a mini neutron source reactor is being built under agreement with the Agency — the Democratic Republic of the Congo — to investigate erosion in the reactor site and the general safety condition of a research reactor in Kinshasa — and Thailand — to assist in the licensing of a new research reactor. Expert missions also visited Viet Nam (Dalat) and Indonesia (Serpong) to assist in improving safety analysis reports.

A mission also visited the Vinça research reactor near Belgrade, Yugoslavia, which was shut down about 15 years ago. In recent years there has been concern about the condition of spent fuel stored in a pond on the site; the primary aim of the mission was to assess the activities conducted to date to improve the condition of the fuel and the pond, and to investigate the current situation. The mission identified a number of safety issues, relating to this fuel and to the fuel still in the reactor, that are not being adequately addressed owing to a lack of funding.

A symposium on research reactor utilization, safety and management, was held in Lisbon in September. The safety issues referred to most frequently at the symposium were those affecting older research reactors, which now



constitute a majority of such reactors worldwide. Specific issues that were discussed included: the management of ageing; updating of safety analysis reports; documents and periodic safety reviews; management of spent fuel; and decommissioning.

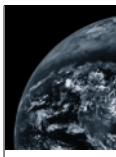
REGULATORY ACTIVITIES RELATED TO NUCLEAR SAFETY

The IRRT service continues to attract new requests and the demand for missions during the next three years is high. During 1999, one full scope IRRT, two pre-IRRT missions and four preparatory visits for missions in 2000 were completed. The IRRT service was originally focused on the regulation of nuclear safety. However, many of the regulatory bodies requesting these missions also have responsibility for radiation, radioactive waste and transport safety, and an increasing number of missions are therefore being conducted by teams that include specialists in these fields.

The Incident Reporting System (IRS), which is operated jointly by the Agency and the OECD/NEA, received 112 event reports in 1999, increasing the total number of reports in the database to more than 2800. The information in the IRS database is for technical use, and has restricted distribution; for unrestricted use, a summary report on operating experience covering 1996 to 1999 was prepared. Two studies of particular categories of events were performed, one on events which indicate a violation of operational limits and conditions, and the other on events connected with the interaction of procedures and human factors.

Y2K PREPARATIONS

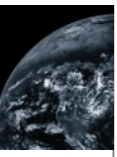
A special project was established to assist Member States in addressing the Y2K computer problem in nuclear power plants (see Annex, Table A6). The Agency's role as a clearing house for information exchange included the setting up of a special Y2K web site to make information widely and easily available. A guidance document was published that outlined the necessary steps to manage the Y2K problem. And three workshops — on planning Y2K programmes, implementation, and contingency planning — were held, with the proceedings and conclusions made available through the Internet site. The Agency also conducted 20 missions to 9 Member States specifically to address Y2K preparations. Special arrangements were also made to ensure that the Agency's emergency response centre was staffed throughout the transition period from 1999 to 2000 so that Member States could have access to authenticated information on safety related Y2K problems at nuclear power plants.



RADIATION SAFETY

PROGRAMME OBJECTIVE

To promote radiation safety through the establishment of relevant safety standards, the application of these standards, the implementation of the Agency's radiation protection rules and requirements, as well as the provision of advice and services to Member States in the framework of the technical co-operation programme and the Conventions on Early Notification of a Nuclear Accident and on Assistance in the Case of a Nuclear Accident or Radiological Emergency.



OVERVIEW

The radiation safety programme has two complementary objectives: development of a unified set of safety standards based on consensus; and provision for the application of these standards in Member States and through other international organizations. In order to achieve these objectives, the programme emphasized a number of areas of work covering the relevant research, the development of requirements level consensus documents and supporting guides, and the preparation of practical manuals and other documents to assist in standards implementation by regulatory authorities. Many of these documents provide the technical underpinning for technical co-operation projects, including the Model Project on strengthening radiation and waste safety infrastructures in over 50 Member States. In addition, considerable effort was devoted to emergency response activities, including servicing of the Conventions on Early Notification of a Nuclear Accident and Assistance in the Case of a Nuclear Accident or Radiological Emergency. To support these activities, research programmes, training courses, conferences and other information exchange meetings were organized through the technical co-operation programme.

RADIATION PROTECTION

In order to quantify the progress achieved so far under the technical co-operation Model Project on upgrading radiation protection infrastructures, a representative group of 14 participating States was visited by Peer Review Teams during the second half of 1999. The teams evaluated the adequacy of the legal and regulatory framework, the empowerment of the regulatory authority to enforce legislation and regulations, the system of notification, authorization and control of radiation sources, existing financial and human resources, and the number of adequately trained personnel. The results from these peer reviews will determine the way forward with respect to the conduct of the Model Project.

As part of a technical co-operation project, software for the Regulatory Authority Information System (RAIS) was translated from English into Arabic, French, Russian and Spanish, and distributed to more than 40 Member States. The software is composed of five modules: inventory of radiation sources and installations; the authorization process, inspection and enforcement; dosimetry of occupationally exposed personnel; and performance indicators for individual installations as well as for the overall regulatory programme.

A new regional technical co-operation project on improving occupational radiation protection in nuclear power plants in the Asian region, together with a similar project for the European region and the Information System on Occupational Exposure (ISOE), are part of an integrated strategy to strengthen the optimization of radiation protection in nuclear power plants, focusing on information exchange and training. Participation in the ISOE — which is administered by a joint secretariat from the Agency and the OECD/NEA — is steadily increasing. By the end of November 1999, ten utilities in nine countries (representing 31 nuclear power reactors) and seven regulatory authorities were members. The Asian project included preparation of a syllabus for training on optimization of radiation protection and training workshops for managers as well as health physicists.

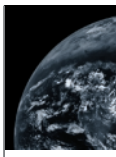
Radiation protection in medical applications is an area of increasing interest. An Agency Safety Guide on radiation protection in medical exposure is being prepared, and reports on medical exposure, prepared in conjunction with WHO, PAHO and the European Commission, have been finalized. A regulatory guidance document on radiation protection and safety in radiotherapy has also been completed. These documents are being published by WHO.

The Y2K computer problem is of particular concern in the medical area in view of the large number of locations around the world using equipment that could be affected, and the amount of non-standard software known to be in use. As part of the Agency's programme of work to address the Y2K problem, two reports were prepared (and made available through the Agency's *WorldAtom* Internet site) on measures to address the problem in medical facilities. A workshop was held in Vienna and two assistance missions were carried out, to Bolivia and Costa Rica, on this subject.

"An action plan was prepared that spells out a programme of measures aimed at improving the control of radiation sources."

SAFETY OF RADIATION SOURCES AND SECURITY OF RADIOACTIVE MATERIAL

In response to the persistent occurrence of incidents involving radiation sources that, for a variety of reasons, were not kept under proper control, an action plan was prepared that spells out a programme of measures aimed at improving the control of such sources. Work was also started on the categorization of sources, an issue which was identified as being of primary importance.



Another area in which the Agency has been active for some years is the investigation of accidents. Recent accidents in Georgia, Turkey, the Islamic Republic of Iran and the Russian Federation were investigated and a database is being developed to bring together the information gathered on the causes and consequences of all of these events. Safety Reports were also finalized on the feedback from operational experience in handling radiation sources, and on lessons learned from accidents in radiotherapy.

The work described above is aimed primarily at dealing with accidental events resulting from carelessness, equipment failure, and lack of knowledge or training. However, the possibility of the deliberate misuse of sources or radioactive material is also a concern.

"A major revision of the Agency's emergency response procedures and associated training was carried out and tested during an international exercise."

Under the terms of a Memorandum of Understanding signed by the Agency and WCO in 1998, increased co-operation was recommended in such areas as information exchange and training. A Joint Technical Committee meeting was conducted in July to review overall progress and to plan further co-operative efforts by the two organizations.

The laboratory testing of border monitoring equipment at the Austrian Research Centre, Seibersdorf, was completed. The selected systems are now being installed at the Austrian/Hungarian border and at Vienna international airport for field testing. On the basis of the laboratory test results, internationally agreed minimum requirements for border monitoring systems were drafted. The main results of this project will be to assist States in selecting, installing and operating detection equipment for land border, seaport and airport monitoring.

In co-operation with WCO and INTERPOL, a five day awareness training course for customs and police investigators on combating nuclear smuggling was held in Vienna in September. Additionally, a joint training course which also included participation by the EuropeanCommission, was held for customs and border control officials in Malta in November.

The Secretariat, working in close co-operation with WCO and INTERPOL, drafted a Safety Guide on preventing, detecting and responding to illicit trafficking in radioactive materials. The regulations, controls and methods described in this Guide are intended to assist customs officers, border police and other law enforcement officers, as well as regulatory authorities and other relevant bodies in Member States, in their efforts to deal with illicit trafficking in radioactive materials. Co-operation with Member States in implementing the recommendations in the Safety Guide will focus on procedures for the detection of radioactive materials crossing borders, as well as on response measures in the event of illicit trafficking incidents.

The Agency's efforts to improve the security of radioactive material included assistance to a Member State to detect lost sources and store them properly after they have been found. This assistance was provided under a technical co-operation project.

SAFE TRANSPORT OF RADIOACTIVE MATERIAL

A new service, the Transport Safety Appraisal Service (TranSAS), was introduced by the Agency to provide reviews, on request, of national implementation of the Agency's Regulations for the Safe Transport of Radioactive Material (the 'Transport Regulations'). The first mission was to Slovenia in June–July 1999. The review appraised Slovenia's legislative framework for the transport of radioactive material and the associated division of responsibilities among the competent authorities, the approval procedures, and inspection and emergency preparedness arrangements.

The requirements contained in the Transport Regulations are being incorporated into the regulations of other international organizations, such as the Recommendations on the Transport of Dangerous Goods Model Regulations of the United Nations, the European road and rail regulations, the International Civil Aviation Organization's Technical Instructions, and the International Maritime Organization's International Maritime Dangerous Goods Code. To encourage and simplify this process, the Transport Safety Advisory Committee approved a new review cycle for the Transport Regulations that is harmonized with the revision cycles of other United Nations organizations. Under the new cycle that starts in 2000, the Regulations will be reviewed every two years and a revised edition produced if necessary.

RADIATION EMERGENCIES

Work continued on a set of revised safety standards on emergency preparedness and response. Particular efforts are being made to secure co-sponsorship of these standards by other relevant international organizations, in order to promote coherence and consistency in the handling of emergencies. A technical document on emergency monitoring procedures was issued during the year and, together with standard training material, formed the basis for two workshops for some 22 countries on emergency monitoring in the Chernobyl 30 km exclusion zone.

A new service, Emergency Preparedness Review (EPREV), was initiated in 1999. A methodology was developed and a first pilot mission using the approach was carried out to Indonesia. The experience gained is being fed back into a revision of the draft implementing procedures.

A major revision of the Agency's emergency response procedures and associated training was carried out and subsequently tested during an international exercise hosted by Canada. A feasibility study for use of the Internet for emergency information exchange was performed, and a detailed proposal developed for an Emergency Response Network describing performance requirements for States wishing to offer assistance under the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency.

The Agency provided assistance on three occasions during 1999 in response to radiological emergencies:

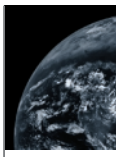
- To Turkey, to advise on the treatment of people overexposed to a cobalt-60 source removed from a container sold as scrap metal, and to assist in locating a possible second source;
- To Peru, to provide medical advice on the treatment of a welder exposed to an unshielded iridium-192 source;
- To Ghana, to assist in returning a jammed industrial radiography iridium-192 source to its container.

In addition, the Agency continued to provide assistance to Georgia in the development of plans to locate and make safe sources abandoned in the country after the breakup of the Soviet Union.

The Agency's Emergency Response System was activated as a result of the criticality accident at the nuclear fuel facility in Tokaimura, Japan. The immediate response was limited to collecting information and disseminating it to Member States, as Japan did not request Agency assistance in dealing with the emergency. A preliminary fact finding mission did, however, visit Japan two weeks after the accident to compile information and to prepare a report on the immediate causes, consequences and aftermath of the accident.

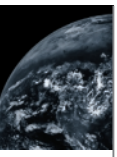
OPERATIONAL SERVICES FOR RADIATION MONITORING AND PROTECTION

The demand for radiation monitoring and protection services for staff of the Agency and technical co-operation experts continued to increase. A total of 445 staff and more than 250 technical co-operation experts were monitored by November 1999, representing an increase of 11 and 25%, respectively, over the last reporting period.



In order to promote the accurate assessment of occupational exposure, the Agency organized international and regional intercomparison exercises. The Agency's dosimetry laboratories were also involved as participants in several intercomparison exercises on individual monitoring, and in a field exercise for mobile monitoring units held in the Chernobyl exclusion zone.

Technical support, through national and regional technical co-operation projects related to radiation safety, was provided in terms of expert advice and the organization of training courses and workshops in individual monitoring, intercompa-rison exercises, quality assurance for radiation protection laboratories and internal dosimetry. Close co-operation was established with other international standards organizations such as the International Organization for Standardization and the International Electrotechnical Commission. Technical support was also provided to emergency missions and field operations, as necessary.



RADIOACTIVE WASTE SAFETY

PROGRAMME OBJECTIVE

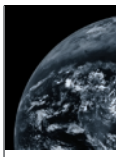
To promote the safe management of radioactive waste, including the safety of disposable, dischargeable and residual waste, through the establishment of relevant safety standards, the application of these standards, as well as the support and service, as required, of relevant international agreements.

OBJECTIVE

The programme on radioactive waste safety focused on the establishment of a comprehensive set of internationally agreed safety standards with the active involvement of Member States and under the supervision of an international advisory committee. A Safety Requirements publication and a Safety Guide on the near surface disposal of radioactive waste were issued, as were two Safety Guides on decommissioning. Several other safety standards, including guidance on the control of discharges, were close to completion. An international symposium was held in Arlington, USA, to address the issue of residual wastes. Advice on specific waste management issues was provided to a number of States, notably those that do not have nuclear power plants and have little infrastructure for managing waste, but need to manage other types of residues, such as those from uranium mining and milling.

SAFETY OF DISPOSABLE WASTE

Pressure has continued for international rules to be agreed to facilitate the release of materials from nuclear facilities. The issue is becoming more urgent with the increasing number of nuclear facilities undergoing decommissioning and with the developing trade in materials for recycling, such as metals and concrete. The Agency is in the process of revising its guidance on the governing principles and criteria for release from regulatory control. In a related development, there has been a reaction from steel manufacturers to the threat of radioactively contaminated scrap metal entering the international



steel pool. The Agency co-sponsored a workshop with the United Nations Economic Commission for Europe on this subject, involving representatives of industry. The workshop resulted in a plan to develop a code of practice to govern and control radioactive contamination in steel scrap.

With the issue in 1999 of a Safety Requirements publication on near surface disposal and its supporting Safety Guide on safety assessment, the attention of the Agency's Waste Safety Standards Advisory Committee turned to the development of safety guidance on the geological disposal of high level radioactive wastes. In its preliminary review of the subject, the areas of existing international consensus were identified, as well as those areas in which expert opinion has not yet converged. One issue currently under study concerns the safety implications of providing for the possibility of future retrieval of wastes from underground repositories. An assessment of this question is currently under way by the Agency and preliminary results were reported at a workshop on the subject of retrievability, held in October near Stockholm and co-sponsored by the Agency. The workshop presented an opportunity for an exchange of views between experts and members of the public on the ethical, safety, safeguards and economic aspects of national policies currently being developed that are aimed at the possible future retrieval of wastes from a repository.

"A report summarizing the history of worldwide disposals of radioactive waste in the oceans was developed."

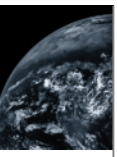
The relevance of the Y2K computer problem for waste management facilities was evaluated and the results were summarized in a guidance document. A workshop was also held to exchange information on the safety measures related to Y2K issues at radioactive waste management and nuclear fuel cycle facilities, focusing on the experience gained, prioritization of activities, 'work-around' strategies and contingency plans. The guidance document and the results of the workshop were distributed to all States and made available on the Agency's Internet home page (*http://www.iaea.org*).

The Agency was requested by the Brazilian regulatory organization to assist in the licensing of a bituminization facility for operational waste at the Angra-2 nuclear power plant. Through its technical co-operation programme, the Agency despatched an expert team that reviewed the facility and made recommendations to the Brazilian counterpart, especially with regard to the need for a commissioning plan for qualifying the facility and for more extensive planning, giving due consideration to the issue of the eventual disposal of the wastes.

SAFETY OF DISCHARGEABLE WASTE

In response to a request from the Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter (London Convention, 1972), a report summarizing the history of worldwide disposals of radioactive waste in the oceans was provided to the 21st Meeting of Contracting Parties to the Convention. The report is an update of a previous survey and includes information on the disposals of the former Soviet Union in the Arctic Seas area. It was developed as part of an information system that will eventually include records of all discharges of radioactive materials into the environment, as well as of solid disposals, and of accidents and losses of radioactive materials at sea.

A set of safety documents which establishes internationally agreed policy and methods for the control of radioactive discharges of radionuclides into the environment is nearing completion. The lead document is a Safety Guide which sets out regulatory principles for the control of discharges; it is supported by a Safety Report which sets out a recommended



methodology for assessing the radiological impact of the releases of radioactive materials to the atmosphere and to surface waters. The two can be used together to develop quantitative release limits which satisfy current international radiological protection principles. Compliance with these limits should be demonstrated by appropriate source and environmental monitoring programmes, as described in another Safety Guide which is also nearing completion.

The current guidance on release control is aimed at achieving adequate protection for human beings living in the environment affected by the discharge. However, there are increasing concerns for the environment itself and for protecting non-human species. As a first step towards developing policy in this area, a discussion document on protection of the environment from the effects of ionizing radiation was issued.

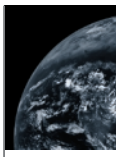
SAFETY OF RESIDUAL WASTE

International policies for guiding the rehabilitation of areas and sites affected by radioactive residues are just beginning to emerge. In order to facilitate the development of a consensus on principles and criteria in this area and to disseminate information on national and international experience, the Agency organized a symposium in Arlington, Virginia, USA. Discussions at the symposium revealed, as expected, that diverse policies are being adopted in various countries at the present time. The meeting helped in starting the first exchanges on the reasons for these differences in approach. It was noted that although the principles of the International Commission for Radiological Protection for intervention are normally the appropriate basis for dealing with contaminated environments, the criteria being adopted in many countries were more like those associated with practices. The symposium stressed the need for continuing efforts by the international community to provide clear advice that is based on scientific principles and sound professional judgement.

In a continuation of its programme of assessments of the radiological conditions at sites affected by nuclear weapons testing, the Agency began work on the examination of locations in Algeria where weapons were tested by France in the 1960s.

In April, the Government of Kazakhstan decided to permanently shut down the BN-350 fast reactor at Aktau. The Agency was asked to assist in the co-ordination of the decommissioning project and provide technical assistance for the planning effort. In August, the Agency hosted a co-ordination meeting to identify concerns associated with preparing the facility for long term storage, leading to a clearer understanding of the problems involved and the identification of assistance that is already being provided through bilateral agreements.

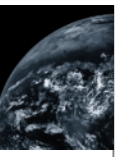
A fact finding mission to Tajikistan made a preliminary assessment of the radiological situation in that country. In particular, the mission team focused on evaluating the safety and security of radiation sources in the context of the existing regulatory system, and the safe handling of radioactive residues from the extensive uranium ore mining and processing activities that took place in the country. The regulatory infrastructure and requirements, and technical capabilities were also reviewed.



CO-ORDINATION OF SAFETY ACTIVITIES

PROGRAMME OBJECTIVE

To ensure the technical consistency of the Agency's safety related functions, as well as coherence with corresponding safety activities carried out by Member States and other international organizations, by promoting the co-ordination of such activities, issuing standards, servicing conventions, providing information about safety policies and standards, and supporting their implementation in Member States through technical co-operation programmes.



OVERVIEW

The safety activities co-ordination programme aims to ensure that there is technical consistency between the Agency's nuclear, radiation and radioactive waste safety activities. This involved work in four main areas: co-ordinating the development and review process for the Agency's safety standards; administering and, where appropriate, implementing the safety related conventions; supporting research and development; promoting safety related information exchange; and co-ordinating the technical input to safety related projects in the Agency's technical co-operation programme.

SAFETY POLICIES AND STANDARDS

The International Nuclear Safety Advisory Group (INSAG) produced four publications. The first report, *The Safe Management of Sources of Radiation: Principles and Strategies* deals with the general principles governing the safety of all sources, and shows that basic nuclear safety, radiation protection and waste safety concepts can be presented in a concrete manner. The second report, *Basic Safety Principles for Nuclear Power Plants*, is an update of 75-INSAG-3 from 1988 and expands on the safety culture concept by citing good practices in safety management and monitoring safety performance. The third publication, *Management of Operational Safety in Nuclear Power Plants*, further develops a set of universal features for an effective safety

management system. The last report, *Safe Management of the Operating Lifetimes of Nuclear Power Plants*, deals with maintaining safety in an ageing installation. With these publications, INSAG completed its fourth three year term.

Activities under the Peer Discussions on Regulatory Practices (PDRP) service included exchange of view on the assessment of regulatory effectiveness. The purpose was to identify common findings and good practices that will assist Member States. Several characteristics of an effective regulatory body were identified that could be used as indicators. The discussions were summarized in a special PDRP series report that aims at the enhancement of good regulatory practices. The conclusion of the report suggested that the assessment of regulatory effectiveness is a combination of traditional methods, including audits, self-assessment of various programmes and their implementation, and new techniques, such as the use of proactive internal safety improvement programmes, and peer reviews and inspections by external organizations.

A total of seven new or revised safety standards (one Safety Requirements and six Safety Guides) were published. A further 72 safety standards are currently in preparation. This figure includes a common safety fundamentals publication (to replace the existing three safety fundamentals covering the nuclear installations, radiation protection and the sources, and radioactive waste management) and nine Safety Requirements, supplemented by a number of Safety Guides, covering the following topics:

- Emergency preparedness and response (two Guides),
- Legal and governmental infrastructure (seven Guides),
- Operation of nuclear power plants (11 Guides),
- Design of nuclear power plants (12 Guides),
- Site evaluation for nuclear power plants (six Guides),
- Research reactor safety (four Guides),
- Predisposal of radioactive waste (six Guides),
- Disposal of radioactive waste (two Guides),
- Rehabilitation of contaminated area (one Guide).

There are an additional 12 Safety Guides in preparation supplementing published Safety Requirements in the areas of radiation safety (eight Guides), discharges of effluents (two Guides) and transport regulations (two Guides). Out of these 72 standards, ten (four Safety Requirements and six Safety Guides) have already been endorsed for publication by the Advisory Commission on Safety Standards (ACSS).

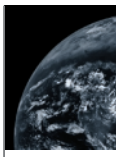
"A major event was the first Review Meeting of the Contracting Parties to the Convention on Nuclear Safety in April for which the Agency acted as the secretariat."

In the general safety category of safety standards (i.e. those standards that are relevant to more than one area of safety), a Safety Requirements publication on legal and governmental infrastructure for safety was approved by the Board of Governors.

A Safety Requirements publication on nuclear power plant design was endorsed by the ACSS and will be sent for approval to the Board of Governors. Another one on power plant operation was approved in September by the Board.

In radiation safety, three Safety Guides on occupational radiation protection, co-sponsored by the Agency and the International Labour Office, were published. These provide generic guidance that is essentially independent of the occupation of the workers.

In waste safety, Safety Requirements publications on the near surface disposal of radioactive waste were published, and those on the predisposal management of radioactive waste, including decommissioning were endorsed by the Board of Governors. In addition, Safety Guides on safety assessment for near surface disposal, on the decommissioning of nuclear



power plants and research reactors and on the decommissioning of medical, industrial and research facilities, were published.

To assist in harmonizing and clarifying the terminology used in different safety standards, a single safety glossary — covering terminology from nuclear, radiation, transport and waste safety — has been developed. This is primarily intended to provide guidance to the drafters and reviewers of safety standards on the way in which the Agency uses particular terms, but may also be of interest to people reading and applying these standards in Member States. The glossary will be made available on the Agency's Internet site.

SAFETY CONVENTIONS

The major event of the year in relation to the safety related conventions was the first Review Meeting of the Contracting Parties to the Convention on Nuclear Safety, which was held in April in Vienna, and for which the Agency acted as the secretariat. As of the end of 1999, there were 52 Contracting Parties to the Convention.

The number of Contracting States to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management passed the half-way mark towards the number needed for the Convention to enter into force. A third informal meeting of signatories and other interested States was held in Vienna in October to develop the rules and guidelines that will govern the review process when the Convention is in force, taking account of the experience gained from the Review Meeting on the Convention on Nuclear Safety. As of the end of 1999, there were 13 Contracting States (9 of which have operational nuclear power plants) and a total of 40 signatories.

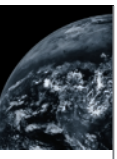
Panama and Belgium became Contracting Parties to the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, bringing the number of Contracting Parties to 84 and 79, respectively. The Early Notification Convention was invoked once, in relation to a cobalt-60 source believed to be missing in Turkey, and the Agency fulfilled its designated functions of notifying neighbouring States and providing information to all Member States. The Assistance Convention was formally invoked in relation to emergencies in Ghana, Peru and Turkey.

SAFETY INFORMATION EXCHANGE

At the yearly meeting of senior regulators, held in Vienna during the regular session of the Agency's General Conference, regulatory effectiveness, the impact of deregulation and management changes on safety, the contamination of transport containers and the Y2K problem were discussed. The regulators generally supported the good practices on regulatory effectiveness as identified in PDRP exchanges and the work on indicators, but warned against using indicators for comparing different countries. They identified the 'de facto' independence of the regulator from political influences as an important condition for making sound technical decisions. With regard to management changes, they expressed the need for regulatory tools to monitor changes in the ownership of plants, management restructuring, and staff cuts. They considered the need for further interpretation of non-fixed contamination levels in the Agency's Transport Regulations.

A handbook on communication in nuclear, radiation, transport and waste safety was published. This publication deals with the principles and methods of communication for a range of target audiences and presents some frequently asked questions, in addition to a summary of the key messages that should be communicated. As a follow-up, a Safety Report is being developed that will assist regulatory authorities in establishing a strategy for ensuring effective communication with different audiences and situations. The publications are aimed at increasing public confidence in the control of radiation sources and in nuclear activities.

A new section on the Agency's Internet site — CoordiNet (*http://www.iaea.org/ns/coordinet*) — gives information on the co-ordination of



safety activities, adding to the existing sections on nuclear safety (NUSAFE) and radiation and waste safety (RasaNet). CoordiNet includes reference information on all of the Agency's safety standards and other safety related publications, on safety related information exchange activities and CRPs, and on the Agency's relations with other international organizations in safety related fields.

The user's manual for the International Nuclear Event Scale (INES) was updated. The INES service received 26 reports in 1999: 14 events were reported from nuclear power plants and 12 from other nuclear facilities. Eight of these events involved radioactive sources. The Level 4 rating (denoting an accident without significant off-site risk) given to the accident in September at the nuclear fuel reprocessing facility at Tokaimura, Japan, was the highest since the scale was introduced in 1990.

SUPPORT TO THE TECHNICAL CO-OPERATION PROGRAMME

Support was provided for more than 150 safety related technical co-operation projects, corresponding to an annual budget of approximately $15 million, and more than 70 training courses and workshops.

A substantial activity in recent years has been the Model Project on upgrading radiation and waste safety infrastructures in more than 50 Member States. A systematic approach to identifying assistance priorities similar to that pioneered in the Model Project is being applied to nuclear safety assistance. The first stage is to develop Country Nuclear Safety Profiles describing the situation in each of the Member States with nuclear power plants receiving Agency assistance. A pilot project in one Member State was completed in 1999.

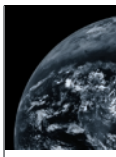
During 1999, 30 nuclear safety training courses and workshops were organized under technical co-operation projects to support regulatory, operating and technical support organizations.

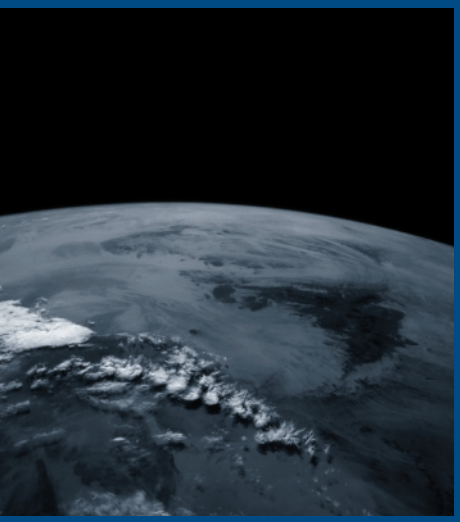
The Agency is developing a set of standardized training courses at three levels: basic (educational) knowledge; general professional competence; and specific areas of expertise. The aim is to not only provide training courses, but also to develop training materials, including textbooks, so that Member States can use these resources in their own training activities. One of the first such standardized courses is the 'Basic Professional Training Course on Nuclear Safety', which is meant for staff of regulatory bodies, reactor operating organizations and technical support groups. This nine week course was organized for the first time in Saclay, France, in co-operation with the CEA Institut National des Sciences et Techniques Nucléaires.

"A substantial activity in recent years has been the Model Project on upgrading radiation and waste safety infrastructures in more than 50 Member States."

In the radiation and waste safety area, 46 training courses and workshops were held, most at the specialized training level. However, the established 'Post-Graduate Educational Course on Radiation Protection', which is now normally held in each geographical region at least every two years, was held in Buenos Aires, Argentina (a long established course in Spanish, which also covers nuclear safety), in Johannesburg, South Africa (in English), in Damascus, Syrian Arab Republic (in Arabic) and in Dubna, Russian Federation (in Russian).

The development of material to support training events has been a major focus of activities to establish a sustainable education and training programme in Member States. Some of the initiatives included: standardization of training material and visual aids; and production of multimedia training materials — including CD-ROMs and videos — in addition to printed matter. And a distance learning project involving Australia, Indonesia, the Republic of Korea, Mongolia, New Zealand, Philippines and Thailand was supported in a trial phase.





The Agency's Programme in 1999: Verification

SAFEGUARDS

PROGRAMME OBJECTIVE

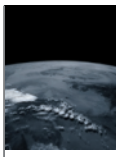
To determine, through the application of the Agency's safeguards system, whether States are complying with the undertakings in their safeguards agreements with the Agency.

OVERVIEW

In fulfilling the safeguards obligations of the Agency in 1999, the Secretariat did not find any indication that nuclear material which had been declared and placed under safeguards had been diverted for any military purpose or for purposes unknown, or that facilities, equipment or non-nuclear material placed under safeguards were being misused. All the information available to the Agency supports the conclusion that the nuclear material and other items placed under safeguards remained in peaceful nuclear activities or were otherwise adequately accounted for.

In 1999, the Agency was in the early stages of implementing protocols additional to safeguards agreements ('additional protocols'). Having completed the evaluation of all the information available to the Agency in respect of two States, including information obtained through activities pursuant to their comprehensive safeguards agreements and additional protocols, the Agency found no indication either of diversion of declared nuclear material or of the presence of undeclared nuclear material or activities in those States. In the case of other States with comprehensive safeguards agreements and additional protocols in force, the evaluaion of the information available to the Agency is not yet complete.

The Democratic People's Republic of Korea (DPRK) remains in non-compliance with its safeguards agreement. The Agency is still unable to verify the correctness and completeness of the initial declaration of nuclear material made by the DPRK and is, therefore, unable to conclude that there has been no diversion of nuclear material in the DPRK. Although the safeguards agreement between the DPRK and the Agency remains binding and in force, the



Agency is able to implement only some of the required safeguards measures in the DPRK. These measures include monitoring the "freeze" on the DPRK's graphite moderated reactors and related facilities, as requested by the United Nations Security Council and as foreseen in the "Agreed Framework" of October 1994 between the United States of America and the DPRK.

Since 1991, the Agency's safeguards activities in Iraq under the comprehensive safeguards agreement concluded pursuant to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) have been implemented as part of the activities carried out by the Agency in Iraq pursuant to United Nations Security Council resolution 687 and related resolutions. In 1999, the Agency was not in a position to implement its Security Council mandated activities in Iraq and could not, therefore, provide any assurance that Iraq was in compliance with its obligations under these resolutions. In these circumstances, given the requirements of its safeguards system, and pursuant to Iraq's safeguards agreement, the Agency scheduled, for December 1999, a physical inventory verification of the nuclear material subject to safeguards in Iraq with the objective of verifying the presence of the nuclear material in question. The inspection could not be carried out in December 1999 because the Government of Iraq provided the necessary visas for the safeguards inspectors only in January 2000.*

As of 31 December 1999, 224 safeguards agreements were in force with 140 States (and with Taiwan, China) (see Annex, Table A14). At the end of 1999, safeguards agreements, which satisfy the requirements of the NPT, were in force with 128 States. NPT safeguards agreements entered into force with Azerbaijan in April. A safeguards agreement pursuant to the NPT and the Southeast Asia Nuclear Weapon-Free Zone Treaty entered into force with Cambodia in December. The Board of Governors approved draft NPT safeguards agreements with Kuwait and Oman. These agreements had not entered into force by the end of the year.

By the end of 1999, Protocols Additional to Safeguards Agreements for 46 States had been approved by the Board of Governors (see Annex, Table A17). Eight such Protocols were in force with Australia, the Holy See, Indonesia, Japan, Jordan, Monaco, New Zealand and Uzbekistan. Furthermore, the Additional Protocol with Ghana was being implemented provisionally pending entry into force.

Through an exchange of letters between Brazil and the Agency, it was confirmed that the safeguards agreement concluded between Argentina, Brazil, the Brazilian–Argentine Agency for Accounting and Control of Nuclear Materials (ABACC) and the Agency for the application of safeguards satisfies the obligations of Brazil under Article III of the NPT and under Article 13 of the Treaty of Tlatelolco to conclude a comprehensive safeguards agreement with the Agency.

OPERATIONS

Major developments with regard to the implementation of Additional Protocols included the following:

- Declarations pursuant to Article 2 of the Additional Protocol had been received from five States and were, or are in the process of being, evaluated and any necessary amplifications or clarifications sought. In addition, measures foreseen under the Model Additional Protocol were implemented in Taiwan, China, including receipt and review of declarations pursuant to Article 2.
- Under the authority conferred by the Additional Protocol, complementary accesses were made in Australia, Uzbekistan and Taiwan, China.

* The planned physical inventory verification inspection took place from 22 to 25 January 2000. The inspectors were able to verify the presence of the nuclear material subject to safeguards in Iraq.

- Implementation trials continued in Japan at two sites with the goal of providing experience to the Agency, State authorities and operators in the implementation of measures foreseen under the Model Additional Protocol. The trials were aimed primarily at gaining practical experience in complementary and managed access for complex nuclear sites, including logistical aspects, managed access and environmental sampling.
- Pending entry into force of the Additional Protocol for countries of the European Union and EURATOM, consultations with EURATOM have started for the implementation of measures foreseen under the Additional Protocol on a trial basis at selected sites.
- The United Kingdom voluntarily submitted an initial declaration of information, in anticipation of the Additional Protocol entering into force. This voluntary declaration is being reviewed by the Agency and then discussed with the Government of the United Kingdom. This voluntary initiative, which may include complementary access trials, will assist the Government and industry to gain experience and develop an awareness for its implementation.

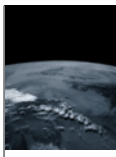
As a first step in the strengthened evaluation process, the nuclear programmes of all States with comprehensive safeguards agreements in force are being evaluated. In 1999, evaluations in 18 States had been reviewed, compared with ten in 1998 and four in 1997. In the second stage, these evaluations will provide a benchmark against which information submitted later under Article 2 of an Additional Protocol will be evaluated. To ensure continuing confidence in the conclusions of the evaluations, they will be updated as warranted by changing circumstances and State Evaluation Reports reviewed annually.

In 1999, environmental swipe samples were collected at eight enrichment facilities in five States and at 28 facilities, including those with hot cells in 19 States (and in Taiwan, China). Initial baseline environmental signatures have now been established and environmental sampling is being introduced into routine use at those facilities.

Various measures and equipment for a strengthened safeguards were implemented in a number of facilities:

- A short notice random inspection (SNRI) scheme was implemented at a low enriched uranium (LEU) fuel fabrication facility in Japan. SNRI rehearsals took place at the three other LEU fuel fabrication plants, and after a trial phase, full implementation is foreseen in 2000 at the four facilities. A safeguards approach which incorporates the use of SNRIs is being tested at a LEU fuel fabrication plant in Spain. The test phase is almost completed and routine implementation is expected in 2000.
- A new safeguards approach for the verification of CANDU spent fuel transfer to dry storage is under discussion with Canada. This approach is based on obtaining 'fingerprints' using non-destructive analysis (NDA) measurements which will provide a unique identity for each canister with spent fuel. The fingerprints will be stored in a database and subsequently used to verify the canister identity at any given time. The approach is aimed at reduction of Agency inspector's presence at the facility during the transportation of the canisters to the storage site.
- New safeguards measures were introduced at two research reactors in Japan. These measures included the installation of a door valve monitor to detect irradiated fuel movements from the core to the spent fuel pit at one reactor and a thermohydraulic power monitor on the primary coolant lines at the other reactor. The latter equipment will be used to confirm the declared reactor

"As a first step in the strengthened evaluation process, the nuclear programmes of all States with comprehensive safeguards agreements in force are being evaluated."



operations and contribute to assurance of the absence of undeclared plutonium production.

- At an enrichment plant in the United Kingdom, an additional continuous enrichment monitor was commissioned in the plant extension, and process load cell readers were calibrated and brought into routine use. Implementation trials of unannounced inspections were carried out at an enrichment facility in Brazil. Routine implementation is expected in 2000.
- A new safeguards approach which includes unattended NDA measurements for a MOX fuel fabrication plant in Belgium was implemented. The approach incorporates 'New Partnership Approach' (NPA) arrangements with EURATOM. A similar approach is being tested in a second MOX fuel fabrication plant in Belgium and is expected to be implemented during 2000.
- Unattended NDA measurement equipment is being used routinely in a facility in Germany where spent fuel elements are loaded into dry storage and transport casks for long term storage. Safeguards approaches based on extensive containment and surveillance (C/S) measures have been approved for medium term storage installations in Belgium and in Germany which store spent fuel in dry storage containers. The nuclear material under these specific measures do not have to undergo re-measurement as long as the C/S measures provide continued assurance on the status and containment of the material.
- Strengthened safeguards measures were introduced at a high enriched uranium (HEU) storage in South Africa, which included the installation of motion detection and a surveillance system with remote monitoring capability.
- Independent or authenticated systems were introduced at a reprocessing plant in Japan to measure and monitor plutonium product solutions and verify transfers of high active solid waste and vitrified waste.
- Shipments of MOX fuel assemblies from Europe to Japan were verified and sealed in Belgium, France and the United Kingdom. Verification and sealing of the MOX fuel assemblies at the fabrication plant is effective and cost efficient, minimizing verification of receipts at the receiving facilities.

"A programme was established for further developing concepts for integrated safeguards as well as the necessary guidelines, approaches and implementation criteria."

Other inspection activities of particular note were as follows:

- Inspections in Yugoslavia resumed without any major problem after an interruption of four months owing to the security situation. A physical inventory verification and baseline environmental sampling were carried out.
- The Agency maintained a continuous presence at the fast breeder reactor in Kazakhstan since October 1998 to verify the fuel canning campaign. More than 2000 assemblies had been measured and packed by October 1999, at which time stabilization of abnormal assemblies and their canning started. This process is due to be completed by the end of 2000.

Co-operation with regional or state authorities was pursued:

- Within the framework of the NPA with EURATOM, co-operation in the area of R&D for safeguards continued as follows: (a) the development of an in situ verifiable transponder seal that could replace metal seals, as well as a new generation of electronic seals; (b) development of a new generation of authenticated digital surveillance systems; (c) development of several NDA techniques for the verification of spent fuel assemblies under Member State Support Programmes; and (d) remote monitoring and data transfer trials were carried out in one facility in Germany and one in Sweden.

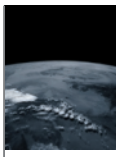
- The co-operation between ABACC and the Agency continued. Procedures were developed for the joint use of equipment for carrying out unannounced inspections and for holding joint training courses.
- The Agency's co-operation with the State's Systems of Accounting and Control (SSAC) of Japan and the Republic of Korea to promote inspection efficiency includes the joint use of safeguards equipment and development of joint use procedures. Discussions on further enhanced co-operation with the SSACs are continuing.

Activities carried out in nuclear weapon States included:

- A Tripartite Enrichment project between China, the Russian Federation and the Agency was completed. This project was aimed at developing an improved safeguards approach in an enrichment plant in China that uses Russian gas centrifuge technology. The measures suggested are now being implemented.
- Following the decision by the USA in 1993 to submit to Agency safeguards nuclear material removed from its nuclear weapons programme, the Agency continued inspections of HEU and plutonium in three facilities. In 1999, the USA submitted an additional 50 tonnes of HEU (for down-blending to LEU) to Agency safeguards. A new safeguards approach was developed and implemented in a newly selected facility.
- In June, technical discussions were held between the Agency and the USA for establishing a safeguards approach for the stabilization of safeguarded plutonium. The stabilization campaign is planned to start after June 2000 and last about six months, after which plutonium will be stored in another facility.
- The implementation of safeguards in the United Kingdom was reviewed to take account of changes in bilateral safeguards agreements. As a result, safeguards at a spent fuel storage facility was discontinued.
- Work continued on developing a system for Agency verification of weapon origin fissile material and other fissile materials determined by the Russian Federation and the USA to no longer be required for defence purposes. In addition, work on a model

Verification Activities

	1997	1998	1999
Inspections performed	2 499	2507	2 495
Person-days of inspection	10 240	10 071	10 190
Seals applied to nuclear material or safeguards equipment, detached and subsequently verified (including seals applied jointly with EURATOM)	24 943	26 824	28 044
Optical surveillance films reviewed	1 500	932	1 271
Video tapes reviewed	4 010	4 884	5 033
Nuclear material samples analysed	888	645	664
Nuclear material analytical results reported	2 150	1 610	1 587
Environmental samples analysed	585	497	511
Nuclear material under safeguards (tonnes)			
Plutonium contained in irradiated fuel	565	593	628
Separated plutonium outside reactor core	57.6	62.4	73.1
Recycled plutonium in fuel elements in reactor cores	5.7	7.2	8.0
High enriched uranium	20.5	21.4	21.2
Low enriched uranium	49 282	49 483	51 191
Source material	108 648	90 622	92 150



verification regime proceeded and the basic technical measures to be employed for the verification of plutonium with classified characteristics, including nuclear weapon components, advanced to the point where full-function prototypes are now under development. Financial arrangements were examined and further work is under way in preparation for the steps required for the adoption and implementation of new bilateral agreements between the Agency, the Russian Federation and the USA.

- In anticipation that the Conference on Disarmament would commence negotiations on a treaty banning the production of fissile material for use in nuclear weapons and other nuclear explosives, the Agency reviewed the technical aspects of relevant verification. The Director General informed the President of the Conference on Disarmament that the Agency was prepared to respond to any request for assistance in the context of a United Nations General Assembly resolution that calls upon the Agency to provide such assistance.

"The Agency informed the President of the Conference on Disarmament that it was prepared to respond to any request for assistance in the context of a United Nations General Assembly resolution that calls upon the Agency to provide such assistance."

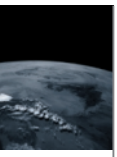
Progress was made in the negotiation of Subsidiary Arrangements to Safeguards Agreements: one new General Part of Subsidiary Arrangements, as well as 117 new or revised Facility Attachments entered into force. The General Part of the Subsidiary Arrangements to the safeguards agreement with EURATOM (INFCIRC/193) was revised and brought up to date. It is expected that this will enter into force in the near future. In addition, the General Part of the Subsidiary Arrangements for an Additional Protocol entered into force for one State.

The Safeguards Analytical Laboratory (SAL) and the Network of Analytical Laboratories (NWAL) analysed 664 samples of nuclear materials and heavy water and provided 1384 results for the material accountancy verification of declarations of facility operators. An additional 181 samples were measured for other safeguards purposes. SAL received and performed screening measurements on 165 environmental samples prior to their distribution to the network of analytical laboratories.

The analytical instrumentation in SAL was improved by the acquisition of a thermal ionization mass spectrometer for nuclear material analysis and a secondary ion mass spectrometer for the measurement of uranium and plutonium in microscopic particles coming from environmental swipe samples. The scanning electron microscope in SAL was upgraded by the addition of two X ray analysing crystals, allowing more sensitive measurements of uranium, plutonium and americium in microscopic particles collected inside hot cells.

The activities of the JNFL project continued to develop a safeguards approach. Work continued on the preparation of the specifications for design, procurement, installation, testing and acceptance of the required equipment and data collection and evaluation systems and the planned on-site analytical laboratory for the JNFL Rokkasho fuel reprocessing plant.

Two rounds of technical discussions took place between the Agency and the DPRK in 1999. While these discussions allowed day-to-day problems to be settled, no major progress was made in resolving long outstanding issues. However, some tangible progress was made on the issue of the preservation by the DPRK of information that the Agency deems necessary for verification of the correctness and completeness of the DPRK's initial declaration. The Agency is still unable to



conclude that no diversion occurred of nuclear material that should have been subject to safeguards.

The Agency's Action Team was unable to implement its mandate with regard to Iraq under the relevant United Nations Security Council resolutions and, as a consequence, to provide any assurance that Iraq was in compliance with its obligations. The team focused on upgrading its computerized information system and its analytical and inspection support tools. It also performed advanced analyses of information accumulated through years of inspections.

A physical inventory verification inspection was scheduled to take place in December 1999 under the Safeguards Agreement between Iraq and the Agency pursuant to the NPT. The inspection was intended to verify nuclear material subject to this agreement at the Tuwaitha storage facility. The verification inspection was performed in January 2000.

DEVELOPMENT AND SUPPORT

With the remote monitoring (RM) project completed in December 1998, implementation began of these systems for safeguards applications. Of particular note were the following:

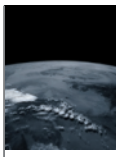
- Seventeen systems were installed and ten were commissioned. A further 25 systems were purchased for installation in 2000. A cost–benefit analysis was carried out in support of future RM implementation planning.
- An RM system was installed at a large research reactor in Canada as part of a new safeguards approach.
- The second phase of an RM project at a MOX fuel fabrication plant in Japan neared completion. The project included the transmission of NDA data from the facility to the Agency's regional office.
- Field trials continued at one LWR in the Republic of Korea and LWRs in Japan. RM systems for routine safeguards use were also installed at two LWRs in Switzerland and at two LWRs and a spent fuel storage in South Africa, with routine implementation planned at all LWRs in Switzerland during 2000.
- Field trials of a complex RM system for the verification of CANDU spent fuel transfer to dry storage in Argentina continued under a joint support programme.
- Plans for the setup of an RM test facility at Agency Headquarters were completed.

Frame relays for the secure transfer of data were implemented in the Agency's Toronto regional office as well as in South Africa.

In the area of equipment development (see Annex, Table A21), ten equipment systems and software were modified and upgraded, 19 were developed and evaluated, and 6 authorized for inspection use. The development of new software for the mini multi-channel analyser, upgrading of the existing electronic VACOSS seal, and development of new electronic sealing devices, and of an improved cadmium–zinc–telluride detector for short-cooling-time spent fuel measurements are in progress. Additionally, a new underwater ultrasonic sealing system was applied on the spent fuel storage at the Cernavoda reactor in Romania.

The introduction of new generation multi-channel analysers proceeded, at the same time as the withdrawal of the ageing ones. A new generation of unattended radiation monitoring systems in CANDU reactors started to replace the aged systems. Digital image surveillance systems continued to be installed. At the end of 1999, 118 digital systems operating 163 cameras were in use. A further 93 systems were purchased for installation in 2000. The first multi-camera digital system was installed for a field trial. Further steps to optimize safeguards equipment utilization were also performed.

A new inspection scheduling system was developed to assist the three operations divisions in the scheduling of inspections. A new system was developed to assist Member States in preparing declarations under Articles 2 and 3 of the Additional Protocol that allows the data to be entered in an electronic format suitable for submission to the Agency.



A number of electronic and physical security measures were implemented to strengthen in-house security, including: measures to reduce the risks of access to the LAN via modems; development of an information security policy and operating procedures; implementation of technical measures, which include implementation of an intrusion detection system; provision of secure remote access and development of a disaster recovery plan; and increased physical protection of one floor by restricting access to authorized staff only.

"A new system was developed to assist Member States in preparing declarations under Articles 2 and 3 of the Additional Protocol."

All applications and information technology infrastructure were made Y2K compliant. In addition, a seminar was held in February to assist Member States in identifying Y2K related problems, and some Member States were given assistance in resolving these issues.

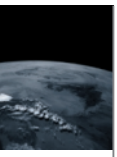
Work continued to prepare for implementation of Additional Protocols and practical experience was gained through actual implementation and through an implementation trial of protocol measures. A simplified set of guidelines for the submission of declarations under Articles 2 and 3 of the Additional Protocol was issued in April for use by States that have little or no nuclear material and/or nuclear activities. Such States have usually concluded a 'Small Quantities Protocol' which holds in abeyance most of the detailed provisions of Part II of a comprehensive safeguards agreement. The Secretariat continued to develop, for internal use, guidelines which seek to ensure that complementary access under the Additional Protocol is carried out in an efficient, technically effective and non-discriminatory manner. Guidelines for sites were completed and are now in use; they include recommendations for selecting places for access within a site. Guidelines for complementary access to decommissioned facilities are being finalized, as are guidelines for other locations declared as having nuclear material.

Work on the strengthened safeguards system was pursued with particular emphasis on integrating traditional nuclear material verification activities with the new strengthening measures. A programme was established for further developing concepts for integrated safeguards as well as the necessary guidelines, approaches and implementation criteria. The first priority for consideration is the development of an integrated safeguards approach for LWRs without MOX fuel. The development programme is being undertaken within, and coordinated by, the Department together with the assistance of a group of safeguards experts, with advice from the Standing Advisory Group on Safeguards Implementation and with the support of a number of Member State Support Programmes. Two technical co-ordinating meetings with participation of experts from nine Member State Support Programmes were held in Vienna to discuss progress in the development of integrated safeguards approaches and to define the direction of future activities.

Under additional protocols concluded on the basis of the Model Additional Protocol (INFCIRC/540), Subsidiary Arrangements are not compulsory but may be requested by a State or the Agency. Model language was prepared and used for the negotiation of such Subsidiary Arrangements.

Model language was also prepared and used for formal reporting under Article 10 of the Model Additional Protocol to States on the Agency's activities performed. Such statements were issued to one State (Australia) concerning the performance of complementary access to sites in that State and the conclusions drawn from these activities.

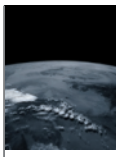
Quality assurance support was provided to enhance the effectiveness and efficiency of the Agency's verification activities. In particular, the Departmental inspection documentation packages (IDP) tracking system became fully



operational, allowing the user to track, on a real time basis, an IDP and to alert the responsible party(ies) to problems requiring corrective action. In 1999, about 3500 IDPs were produced by the inspectorate and were subject to systematic quality control checking. The quality of the seals verification system continued to be monitored through the use of deliberately altered seals and blind testing, with 91 such blind tests performed. In addition, the quality of surveillance review was monitored through re-review of randomly selected films and tapes and in-depth reviews of the surveillance application. During the year, such re-reviews were performed for 7 inspection reports.

The safeguards training curriculum was further enhanced with new training courses that address the need for increased skills and knowledge of safeguards staff and Member State personnel. In addition to regular courses for inspectors on 'traditional' safeguards, training on the implementation of strengthened safeguards was conducted, particularly in the fields of: evaluating information from States and preparing State evaluation reports; fulfilling security requirements for information; updating and upgrading inspector knowledge of strengthened safeguards principles and practices; and further enhancing inspector knowledge of nuclear fuel cycle and proliferation indicators. Member State personnel also received training to assist them in fulfilling their obligations under safeguards agreements. International and regional training courses were conducted for SSAC personnel and the topics included strengthened safeguards, with focus on the Model Additional Protocol, Member State requirements arising from Articles 2 and 3 of the Model Additional Protocol and other related subjects.

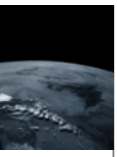
At the request of the Board of Governors, new reports were prepared that provided additional information on the legal, technical and financial implications of the various options to address the proliferation potential of neptunium and americium. In September, the Board decided to authorize the implementation of an approach to monitor neptunium and to defer the question of its application to americium until a later date. By the end of 1999, the Agency had initiated an exchange of letters with the concerned States for the receipt of information and the application of measures required for the monitoring scheme for neptunium.



SECURITY OF MATERIAL

PROGRAMME OBJECTIVE

To assist Member States, through training, expert assistance, equipment and exchange of information, in the protection of nuclear and other radioactive materials against forcible seizure, theft and other criminal activities and to provide them with the knowledge and tools for detecting and responding to incidents of trafficking should they occur.



OVERVIEW

The focus of the programme on the security of material was to assist Member States in the establishment of systems necessary to prevent nuclear material and other radioactive sources from being diverted to unauthorized purposes. Further enhancements to the information exchange process were accomplished during the year and the number of States participating increased from 60 in 1998 to 68 in 1999. Training programmes specifically tailored to address the needs of State regulators, customs officials and border police were held. Building upon prior joint efforts, WCO, INTERPOL, the European Commission and the Agency provided training in Vienna and Malta. Laboratory tests of detection and monitoring equipment were completed, and field testing started. The development of international standards for the physical protection of nuclear material were addressed in numerous meetings and seminars, all with the goal of enhancing the strength and uniformity of these standards.

The narrative that follows focuses on the security of nuclear material. Information on Agency activities related to the security of radioactive material other than nuclear material — the protection of which is primarily a safety concern — can be found in the chapter on 'Radiation Safety'.

INFORMATION

As part of its efforts to encourage Member States to participate in the Illicit Trafficking Database Programme, the Agency organized a regional seminar in

Kazakhstan in December. The seminar demonstrated the determination of the Central Asia and Caucasus region to co-operate in combating illicit trafficking; in addition, the seven participating States announced their intention of joining the Illicit Trafficking Database Programme.

Major upgrades were made to the software used to maintain the illicit trafficking database. These upgrades reflect the expanded scope and content of the database, which allows for an increased level of reporting from multiple sources. Additionally, the retrieval and dissemination capabilities of the database were enhanced. While past years have seen a decrease in the annual number of incidents reported, this has not been the case in the last two years. A detailed analysis is being carried out to identify the reasons for this increase.

PROTECTION OF NUCLEAR MATERIAL

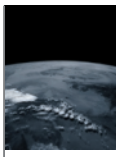
The Agency's programme to enhance the protection of nuclear material is a recent development. It started with Board of Governors approval in 1995 of activities to assist States and for the provision of extrabudgetary funds for this purpose. The programme continued to advance in 1999, with States providing more regular budget funding. In addition, INFCIRC/225/Rev.4 was published. A number of actions are being taken to provide additional guidance to States and enhance the global implementation of the recommendations contained in it. In other work, the Agency convened an expert meeting to consider whether there is a need to revise the Convention on the Physical Protection of Nuclear Material. This effort will continue with a thorough review to determine the basis for possible revision. Finally, a design basis threat workshop was conducted in Prague at the request of the Czech Government.

The Agency continued to receive requests for International Physical Protection Advisory Service (IPPAS) missions to appraise the national protection systems of requesting States. During 1999, there were IPPAS missions to Lithuania and Peru, plus a preparatory mission to Belarus. The Agency provided follow-up support to these and earlier IPPAS missions. Donors and recipients from the Newly Independent States met in March to ensure proper co-ordination of technical co-operation in the field of physical protection. Plans for addressing the needs of the individual States were also developed. At another meeting of the donor and recipient States, the 4th Annual Review Meeting for the Co-ordinated Technical Support Programme (CTSP), held in Vienna in November, a consensus was reached on the need to address the sustainability of nuclear control systems and for training and equipment to combat the illegal use of nuclear material.

"Major upgrades were made to the software used to maintain the illicit trafficking database."

A physical protection course on system design was held in the Czech Republic for individuals from eastern European States and the former Soviet Union. A workshop to provide an introduction to the field of physical protection was held in Cyprus for officials from the Middle East and North Africa. Regional workshops designed to assist States in strengthening their nuclear material control systems based on Agency safeguards were held in Belarus in May and in Uzbekistan in October.

The Agency contributed to the programme of the G-8 Non-Proliferation Experts Group (NPEG) by maintaining the NPEG list of State points of contact whose main function in a crisis situation would be to channel essential information to senior policy makers in a timely manner. A test of this system was carried out in June to identify possible improvements to the system.



The Agency's Programme in 1999: Management and Outreach

MANAGEMENT, CO-ORDINATION AND SUPPORT

PROGRAMME OBJECTIVE

To provide overall direction, policy guidance, legal advice, co-ordination and administrative support to effectively and efficiently implement the Agency's mandate as reflected in the approved programme.

LEGAL ACTIVITIES

Legislative assistance continued to be provided to Member States to enable them to further develop their nuclear legislation. Emphasis was placed on the interaction between technical and legal experts of the Agency and those of Member States. In particular, assistance was given to five Member States by means of written comments or advice on specific national legislation submitted to the Agency for review. Advice was also provided on:

- Legislative issues related to radioactive waste management (for the Baltic countries);
- Legislative issues related to the development of a legal infrastructure governing radioactive waste resulting from uranium mining and milling and decommissioning (for countries of East and Central Europe and the Newly Independent States);
- Reform of civil nuclear liability (in co-operation with the OECD/NEA and the European Commission);
- Basic definitions for use in a national nuclear law regime and the independence of the regulatory body (for the European region);
- Consolidation of an adequate legal framework for the safe and peaceful uses of nuclear energy (for countries of East Asia and the Pacific);
- Development of a legal framework governing civil liability for nuclear damage and for preparedness and response to radiological emergencies (for countries of East Asia and the Pacific);
- Drafting of nuclear legislation.

PUBLIC INFORMATION

The Director General approved a new public information and outreach policy. This policy is intended to enhance the Agency's interaction with opinion leaders, the media and civil society, reaching out to both traditional and non-traditional partners, for instance among non-governmental organizations and the private sector.

The Agency's *WorldAtom* Internet site was redesigned to improve its ability to handle an expanding number of external enquiries. The on-line information base was enlarged, notably in the areas of safety, nuclear energy, research reactors and nuclear fuel cycle facilities, and a special series of pages was introduced for prompt coverage of topical Agency activities and nuclear events attracting media and public interest.

"A new public information and outreach policy is intended to enhance the Agency's interaction with opinion leaders, the media and civil society."

New publications included a comprehensive brochure on the work of the Agency's Laboratories at Seibersdorf. In addition, a number of exhibits were organized both in Vienna and in Member States, and five public information seminars were held in China, Cuba, Czech Republic, Egypt and Japan.

Among new films released to Member States and to other outlets, apart from Agency productions on Semipalatinsk, isotope hydrology and illicit trafficking, were two films financed essentially from extrabudgetary sources. The first, *Harnessing the Atom*, deals with the Agency's role in peaceful nuclear applications, non-proliferation and safety, while the second, *Three Voices*, was on women who are pursuing nuclear related careers and are currently serving in the Agency.

FINANCIAL MANAGEMENT

At its June meeting the Board of Governors adopted amendments to the Agency's Financial Regulations with effect from 1 January 2002, so that full biennial programming could be implemented for the 2002–2003 cycle. The Board also suspended the application of Financial Regulation 3.01, exceptionally, for the year 2001, the transitional period. In September, the General Conference approved an amendment to Article XIV.A of the Statue to allow for biennial budgeting. Once this amendment comes into force, the Agency will be able to operate under biennial appropriations as a corollary to biennial programming, as is the practice in other United Nations system organizations.

May saw the completion of the implementation plan of the new Agency Financial Information Management System (AFIMS). Owing to time constraints and the Y2K problem facing the present Financial Information and Control System (FICS), the objective of Phase I (planned for January 2000) was to implement the system based on a minimum set of requirements. Discussions and preparations for Phase II (planned for mid-2000 following migration and 'settling-in') commenced in late 1999. In the last week of December, the transfer of account balances from FICS to AFIMS was successfully carried out. The new system went into operation on 1 January 2000.

For 1999, the General Conference appropriated an amount of $224.2 million for the Agency's Regular Budget on the basis of an exchange rate of 12.70 Austrian schillings to one United States dollar, of which $219.3 million was related to Agency programmes (see Annex, Table A1). The latter amount was adjusted to $216.9 million to account for the average United Nations exchange rate (12.8671 Austrian schillings to one US dollar) actually experienced during the year.

The Regular Budget for 1999, at an exchange rate of 12.8671 Austrian schillings to one US dollar, amounted to $221.8 million, of which $212.2 million was to be financed from contributions by Member States on the basis of the 1999 scale of assessment, $4.9 million from

income from reimbursable work for others and $4.7 million from other miscellaneous income.

The actual expenditures for the Agency's Regular Budget in 1999 amounted to $221.5 million, of which $216.5 million was related to the Agency's programmes. The unused budget from the Agency's programmes amounted to $0.4 million, while the total unused budget was $0.3 million when account was taken of reimbursable work for others.

The target for voluntary contributions to the Technical Co-operation Fund for 1999 was established at $73 million, of which $64.1 million was pledged by Member States.

A total of $26.1 million in extrabudgetary funds was provided by Member States, the United Nations, other international organizations and other sources during 1999 (see Annex, Table A2). Of this amount, $10.3 million was in support of safeguards, $4.1 million was for technical co-operation projects, $1.9 million for food and agriculture, $2.5 million for nuclear safety and $1.9 million for implementation of United Nations Security Council Resolution 687 on Iraq. An amount of $1.2 million (supplemented by the Agency's contribution of $3.1 million) was in support of IAEA-MEL. The remaining $4.2 million was in support of various other projects implemented by the Agency.

A total of $1.9 million was administered on behalf of research institutions and $2.4 million for the International Thermonuclear Experimental Reactor.

PERSONNEL MANAGEMENT

The design and testing of a comprehensive management training programme was completed. The aim is to foster good management practices within a common framework of policies, procedures and terminology throughout the Agency. Implementation commenced in November and will continue through 2000 and 2001 to train managers at all levels.

A human resources planning process was developed which will ensure a holistic approach to human resources management and help determine the appropriate size and composition of the work force in each area. It will also support the implementation of the staff rotation policy by identifying those functions which require institutional memory and continuity as opposed to those that necessitate a continuous influx of fresh talent. And it will also serve as a basis for a projection of vacancies, which will enable the Secretariat to begin planning for the recruitment of prospective candidates at an earlier stage.

At the end of 1999, there were 2212 staff members of the Secretariat — 944 in the Professional and higher categories and 1268 in the General Service category. These figures represent 1652 regular, 296 temporary assistance and 174 extrabudgetary staff, as well as 58 cost free experts and 32 consultants. Ninety-two nationalities were represented among the 682 staff members in posts subject to geographical distribution.

"Many of the goals outlined in the Agency's Medium Term Strategy explicitly mention the full use of information technology"

INFORMATION MANAGEMENT

Many of the goals outlined in the Agency's Medium Term Strategy explicitly mention the full use of information technology (IT). Specific activities in support of these goals included the development of an information management module for the Management Certificate Curriculum, as well as projects on the rationalization of databases and an Agency-wide document management system.

COMPUTER SERVICES

Considerable time and effort was invested to deal with the Y2K computer problem. The complete IT infrastructure was tested and,

where needed, corrective measures were put into place. A major effort to ensure Y2K readiness was completed by November, as well as a 'Staging Room' to assist other parts of the Agency with Y2K testing of their own applications, in particular for the financial system FICS. In addition, the installation of an uninterruptible power supply meant that the central computer systems and network infrastructure are now fully protected against unplanned power interruptions. A contingency and transition plan was prepared to minimize the effect of remaining Y2K problems.

Discussions were held late in 1999 with the Microsoft Corporation on improving and streamlining Agency licensing. The Agency is in the process of finalizing an MS Enterprise Licensing agreement with Microsoft that will help it to reduce the total cost of ownership through cost savings associated with standardization, aggregation of worldwide software needs at the best possible discounts, and reduction of overhead costs associated with ongoing license tracking and ordering.

Progress in creating an Agency-wide Contacts Information System was made with migration of the Mailing List system from the mainframe to a client/server environment. In addition, operational support was provided for *OASIS*, the Agency's general Intranet site, and the Country Files Systems.

Programme specific tasks included:

- Support of a major redesign and development of the INIS Data Processing System;
- Extension of the Power Reactor Information System to cover non-electrical applications of nuclear power plants;
- Design and development of Internet sites for research reactors and the Isotope Hydrology Information System;
- Development of a system to aid in the maintenance and publication of the Administrative Manual.

LIBRARY SERVICES

The second release of the VIC Library's home page, *VICLNET*, was developed and made available to the users. The main benefit is streamlined user access to electronic information. In addition, 72 subscribed electronic journals, 190 free Internet journals and 4 broad commercial electronic information services were made available through *VICLNET*, as were on-line searching, ordering and electronic delivering technical reports and standards from both the VIC Library collections and external sources. Furthermore, a CD-ROM network was developed and put in operation as a service component integrated with the home page.

The VIC Library migrated to a new integrated library software system, *STAR/Libraries*. The system provides opportunities for further streamlining of user access to electronic information resources and for developing new services for Library users. It will also help to improve efficiency and effectiveness of all library operations.

CONFERENCE, PRINTING, PUBLISHING AND TRANSLATION SERVICES

During 1999, the Agency's publishing, printing and documentation, conference, and language services were amalgamated into one organizational entity. Work thereupon began on improved co-ordination and streamlining of activities, especially through Internet based systems, that will have upstream benefits as well. The *Nuclear Fusion* journal's Internet site was enhanced, and work was initiated on an Agency e-commerce site for sales publications.

The total output of translations and official records was 26 501 standard pages, as compared with 28 875 the previous year. This decrease is attributed mainly to restrictions imposed on the number and length of documents and to reduced internal demand for translation. In the printing area, the total amount of printed copies, and related work (in relation to Agency programmes and not including reimbursable work for others) was 75 016 012 pages, down from the 1998 figure of 84 586 953. Publishing activities included the production of a total of 142 books, reports,

journal issues and booklets in English (see Annex, Table A27). In addition, there were two publications in Chinese, two in French, one in Russian and one in Spanish.

INTERNATIONAL NUCLEAR INFORMATION SYSTEM (INIS)

The current number of participating Members is 122, including 103 countries and 19 international organizations. The INIS Database on the Internet received a large number of requests for registration in 1999. The total number of paid and free registrations was 1136 (for a total of 3210 users). The INIS Database continued to be offered on CD-ROM, with a total of 448 paid and free subscriptions distributed in 1999

Under the co-operative arrangement between the Agency and the OECD/NEA Data Bank, 406 computer programs (out of 4667) were distributed to users in the Agency's Member States who are not members of the OECD. Two programs (out of 62) were contributed.

Two new modules for the INIS Data Processing System were implemented, the Output Products Sub-system (OPS) and the INIS Registration System (IRS). The IRS enables on-line registration of all input material — bibliographical records and associated non-conventional literature (NCL) full texts — in hard copy or electronic format. It also streamlines submission of NCL directly to the INISIS imaging system.

During the year, 3259 NCL documents were imaged by the INIS Clearinghouse for a total of 234 309 pages scanned. Scans from a further 6217 documents were also sent by Member States for a total of 413 094 pages. The overall total in 1999 is of 9476 documents (647 403 pages). In addition, 50 CD-ROMs were produced during the year for a total of 131 CD-ROMs since imaging began. All NCL CD-ROMs are now being produced in-house, resulting in significant savings to the Agency. To provide guidance on the continued operation of INIS, the 27th Annual Consultative Meeting of INIS Liaison Officers was held in May in Vienna. This, the largest gathering of Liaison Officers ever, produced a number of decisions and recommendations: for example, it was decided to revise the INIS Membership Agreement.

The Fifth INIS/ETDE Joint Technical Committee met in October in Knoxville, USA. Discussion items included a variety of topics of common interest to both INIS and ETDE.

Significant outcomes of the meetings referred to above were the adoption of a simplified, common INIS/ETDE subject categorization scheme to be operational as of 1 January 2000, and a decision to complete the reconciliation of the INIS and ETDE Thesauri so as to produce a single INIS/ETDE Thesaurus by the end of the first quarter of 2000. It is expected that these two actions will result in a reduction of the cost of input preparation while improving the consistency of subject analysis.

The availability of new technology facilitated the implementation of a distance learning project on the Internet to provide training to INIS users. The first phase of the project was completed in 1999. Some of the advantages of distance learning include: just in time training, as well as continuous access to training facilities; equal access to training opportunities; availability of specific training to individual users; easy updating of course content; and the facility for users to set their own pace in acquiring training.

MANAGEMENT OF TECHNICAL CO-OPERATION FOR DEVELOPMENT

PROGRAMME OBJECTIVE

To provide management support to effectively and efficiently design, implement and evaluate the technical co-operation programmes.

OVERVIEW

This past year saw both the start of implementation of the 1999–2000 technical co-operation programme and the start of planning for the 2001–2002 programme. While uncertainty regarding the level of pledges that would be received was a factor that complicated planning throughout 1999, the year ended with pledges at a record high. In addition to managing fluctuating pledge levels, a major challenge was met in preparing all information technology systems in the programme for alignment with the Agency's new financial information system in 2000, and in migrating all of the remaining applications from the mainframe to the SQL server.

TECHNICAL CO-OPERATION PROGRAMME

A major tenet of the 'Strategy for Technical Co-operation' is ensuring that the programme is relevant to Member States and contributes directly to the achievement of major sustainable development priorities of recipient countries. It has also been shown that good planning and design up front is the key to good results during project implementation. A major focus of effort for the Agency, therefore, was 'upstream' work for the 2001–2002 programme.

One method used to ascertain the interests and priorities of Member States was the organization in the Europe programme of seven separate regional meetings. These were in addition to the nearly 120 regional events organized to implement this regional programme. These meetings enabled the countries

of the region to: (a) discuss and define their priorities; (b) participate in training on project design; and (c) plan specific projects together before the actual submission of project requests.

A case in point was the November meeting called to plan regional nuclear safety and energy related projects. Senior officials from regulatory authorities and nuclear plants from countries throughout the region met at the Agency together with representatives of donor countries and organizations. The result was agreement on detailed project workplans for 2000 and on the scope of major projects for the 2001–2002 cycle in the fields of nuclear safety and energy.

Another means of ensuring relevance in the Agency's programme has been to align its objectives with those of other United Nations agencies. In Africa, for example, one of WHO's main areas of focus is communicable diseases, in particular malaria and tuberculosis. The recent resurgence of TB is a major public health concern in countries such as South Africa. The Agency has started to work with that country to develop isotope based molecular techniques for the rapid and accurate detection of multidrug resistant strains of TB. It is hoped that this will not only benefit the community, but will also contribute to international and WHO efforts to combat TB.

Similarly in West Asia, the Agency's planning efforts in the area of water resources management was harmonized with the work of other international and intergovernmental organizations such as UNESCO, the United Nations Economic and Social Commission for West Asia, the Arab League Educational, Scientific and Cultural Organization and the Arab Centre for the Studies of Arid Zones and Dry Lands. At a co-ordination meeting in February 1999, representatives of these organizations helped to develop the scope and objectives of a regional project to use isotope hydrology to assess the effectiveness of artificial groundwater recharge through surface reservoirs, and to manage groundwater aquifers deteriorated by salinity. These isotope studies are envisioned to be integrated with the water resource projects of the above mentioned organizations.

While harmonization of the Agency's work with that of other organizations helps to ensure the relevance and impact of Agency programming, forging links with the private sector can lead to sustainability of results. In 1999, the East Asia and Pacific region sponsored a seminar to assist project counterparts in marketing their capabilities to end users. Case studies from Indonesia and Malaysia demonstrated how those countries integrated some of their research and development activities with the production system in the country. Examples from China and Pakistan showed how R&D had been commercialized directly or through subsidiary companies. In all four cases there was the clear message that if nuclear institutions are to stay relevant in the context of mainstream socioeconomic development, they can best do so by generating revenues, thus achieving self-reliance and sustainability.

"...harmonization of the Agency's work with that of other organizations helps to ensure the relevance and impact of Agency programming..."

Self-reliance was also a theme in Latin America, where at their 16th Technical Co-ordination meeting, Member States of ARCAL agreed on procedures for the selection of Regional Resource Centres. Thirty-one initial candidate centres were selected from a list of 65 potential centres; many of these have now been reviewed by the Agency. Those technically qualified will be presented to ARCAL members for the final selection. It was agreed that the list of designated centres — covering all parts of the region and many different topics — will be reviewed every three years. Three institutions are already operating as Regional Resource Centres, specializing in the repair and maintenance of different types of nuclear instrumentation.

Since 1999 was the first year in the programming cycle, a major effort was also made to improve project quality through the training of national counterparts prior to the submission of project requests to the Agency. A new training package on project design and planning was developed at the Argonne National Laboratory with financial support from the US Department of Energy. The package included training in the use of a monitoring tool designed by the Agency to strengthen implementation of projects in the next cycle. Several follow-up workshops were later organized by course participants in their own countries.

"The Agency's technical co-operation programme received strong support from Member States in the form of increased contributions to the TCF."

PLANNING, CO-ORDINATION AND EVALUATION

Among the tools used to design programmes with individual countries and regions during upstream work are the outputs of Thematic Planning exercises. Two such exercises were undertaken in 1999 in the fields of dam safety and sustainability, and fruitfly control. The latter exercise was particularly innovative in that it: (a) established research priorities for the Agency's technical departments and programming possibilities for its technical co-operation programme that could intersect over an extended time frame; and (b) established the goal of improving the cost effectiveness of this technology by taking a medfly sterile insect technique package to the marketplace.

Programming is complemented and informed by evaluation. In 1999, an evaluation of the Agency's technical co-operation activities over a ten year period related to research reactors and low energy accelerators was undertaken jointly with a review of Regular Budget activities in the same field. The evaluation concluded that the projects in this area were highly relevant, indicating that the countries themselves committed substantial resources to the projects and that the Agency inputs were appropriate for meeting the project objectives. Along the same lines, the good effectiveness ratings indicated that the projects met their specific objectives. Through positive efficiency scores, the Agency concluded that their inputs were used appropriately and in a timely and cost effective manner. However, lower scores for impact indicate problems converting the inputs into tangible socioeconomic benefits through effective end-users. Several recommendations grew from an analysis of the evaluation. The number of Model Projects in this area should be increased. Regional planning is needed to avoid overestimating latent demand or not valuing risks in market saturation. Feasibility studies, cost–benefit analyses and contingency funding must be used to better manage the risk factors associated with these projects. Finally, priority should be given to existing problems of safety and waste management before encouraging more investments in new facilities.

The Agency's technical co-operation programme received strong support from Member States in the form of increased contributions to the Technical Co-operation Fund (TCF). However, there were significant fluctuations in the estimated resources, and some major pledges and contributions were received only in the last month of the year.

To cope with this uncertain situation, the Agency relied on the principle of 'dynamic programming'. The primary 'safety valve' was a larger than usual number of 'footnote a/' projects that could be upgraded not only with extrabudgetary funds, but also with funding from late pledges; more than $5.6 million worth of projects were upgraded throughout the year. These were rigorously selected using the following criteria: (a) high quality; (b) cost sharing from either the recipient government itself or another donor; and (c) 'due account'

considerations (i.e. taking into consideration a country's record in pledging and paying contributions to the TCF and, if applicable, its assessed programme costs). Preference was also given to regional projects so that a maximum number of Member States could benefit from the upgrading of footnote a/ projects. The programme also benefited in 1999 from a substantial reduction in standard expert costs.

One of the major tasks undertaken by the Agency in 1999 was the development of interfaces between technical co-operation applications and the Agency's new financial information system. This was complemented by the need to replace outstanding systems and system components still running on the mainframe with client server based solutions. In addition, workflows for technical co-operation financial processes were streamlined and project budgeting and financial controlling simplified. The cycle times for technical co-operation financial processing have been substantially shortened and more up to date data have been made available.

Annex

Table A1. **SUMMARY OF ALLOCATION AND UTILIZATION OF REGULAR BUDGET RESOURCES IN 1999**

Programme	1999 budget GC(42)/7 (at AS 12.70) (1)	1999 adjusted budget (at AS 12.86) (2)	1999 total expenditure Amount (3)	1999 total expenditure % of adjusted budget (3) / (2)	Unused (over-expended) budget (2)–(3) (5)
Nuclear Power	4 453 000	4 409 000	4 468 025	101.34	(59 025)
Nuclear Fuel Cycle and Waste Technology	5 233 000	5 182 000	5 133 808	99.07	48 192
Comparative Assessment of Energy Sources	2 909 000	2 881 000	2 867 694	99.54	13 306
Subtotal	**12 595 000**	**12 472 000**	**12 469 527**	**99.98**	**2 473**
Food and Agriculture	10 566 000	10 474 000	10 474 114	100.00	(114)
Human Health	6 019 000	5 968 000	5 953 687	99.76	14 313
Marine Environment, Water Resources and Industry	6 516 000	6 452 000	6 422 342	99.54	29 658
Physical and Chemical Sciences	8 835 000	8 768 000	8 781 845	100.16	(13 845)
Subtotal	**31 936 000**	**31 662 000**	**31 631 988**	**99.91**	**30 012**
Nuclear Safety	5 593 000	5 533 000	5 603 006	101.27	(70 006)
Radiation Safety	3 382 000	3 346 000	3 397 856	101.55	(51 856)
Radioactive Waste Safety	2 130 000	2 107 000	2 183 749	103.64	(76 749)
Co-ordination of Safety Activities	3 062 000	3 029 000	2 824 610	93.25	204 390
Subtotal	**14 167 000**	**14 015 000**	**14 009 221**	**99.96**	**5 779**
Safeguards	79 752 000	78 876 000	78 984 983	100.14	(108 983)
Security of Material	1 060 000	1 049 000	926 227	88.30	122 773
Subtotal	**80 812 000**	**79 925 000**	**79 911 210**	**99.98**	**13 790**
Management of Technical Co-operation for Development					
Technical Co-operation Programme	7 845 000	7 753 000	7 965 819	102.74	(212 819)
Planning, Co-ordination and Evaluation	4 824 000	4 770 000	4 541 814	95.22	228 186
Subtotal	**12 669 000**	**12 523 000**	**12 507 633**	**99.88**	**15 367**
Management, Co-ordination and Support					
Executive Management	5 041 000	4 983 000	4 774 382	95.81	208 618
Policy making Organs	6 374 000	6 306 000	6 457 470	102.40	(151 470)
Legal Activities, External Relations and Public Information	7 036 000	6 964 000	6 355 036	91.26	608 964
Administration	12 585 000	12 440 000	12 480 472	100.33	(40 472)
General Services	22 322 000	22 044 000	22 339 865	101.34	(295 865)
Information Management and Support Services	13 752 000	13 597 000	13 613 958	100.12	(16 958)
Subtotal	**67 110 000**	**66 334 000**	**66 021 183**	**99.53**	**312 817**
Total – Agency Programmes	219 289 000	216 931 000	216 550 762	99.82	380 238
Reimbursable work for others	4 958 000	4 901 000	5 008 883	102.20	(107 883)
TOTAL	224 247 000	221 832 000	221 559 645	99.88	272 355

Table A2. **EXTRABUDGETARY PROGRAMME FUND, 1999 (*resources and expenditures*)**

Programme	Resources			Total expenditure	Unused balance as at 31 December 1999
	Unused balance as at 1 January 1999	Receipts	Adjusted budget		
	(1)	(2)	(1) + (2) (3)	(4)	(3)–(4) (5)
Projects funded by individual Member States					
Nuclear Power	233 546	117 200	350 746	104 782	245 964
Nuclear Fuel Cycle and Waste Technology	289 846	514 130	803 976	409 707	394 269
Comparative Assessment of Energy Sources	136 104	154 151	290 255	183 266	106 989
Food and Agriculture	729 422	66 856	796 278	548 835	247 443
Human Health	307 212	118 000	425 212	118 832	306 380
Marine Environment, Water Resources and Industry	1 151 823	865 536	2 017 359	801 430	1 215 929
Physical and Chemical Sciences	26 998	85 956	112 954	53 457	59 497
Nuclear Safety	1 609 601	2 461 128	4 070 729	1 656 247	2 414 482
Radiation Safety	85 401	406 000	491 401	204 289	287 112
Radioactive Waste Safety	53 211	44 936	98 147	31 923	66 224
Co-ordination of Safety Activities	181 152	146 332	327 484	137 042	190 442
Safeguards	9 945 387	10 321 412	20 266 799	13 538 686	6 728 113
Security of Material	424 782	897 240	1 322 022	287 710	1 034 312
Management of Technical Co-operation for Development	162 136	265 656	427 792	253 025	174 767
Executive Management	557 235	750 577	1 307 812	807 458	500 354
Services for Policy Making Organs	0	22 835	22 835	14 281	8 554
Legal Activities, External Relations and Public Information	623 592	625 718	1 249 310	700 172	549 138
Administration	38 219	22 000	60 219	55 859	4 360
Subtotal	**16 555 667**	**17 885 663**	**34 441 330**	**19 907 001**	**14 534 329**
Multi-funded projects					
Nuclear Power	105 928	0	105 928	41 570	64 358
Nuclear Fuel Cycle and Waste Technology	25 716	114 288	140 004	85 936	54 068
Food and Agriculture	167 877	124 776	292 653	92 491	200 162
Nuclear Safety	101 257	0	101 257	68 962	32 295
Co-ordination of Safety Activities	54 299	0	54 299	54 299	0
Subtotal	**455 077**	**239 064**	**694 141**	**343 258**	**350 883**
International organizations					
Food and Agriculture	99 602	1 731 061	1 830 663	1 697 645	133 018
Marine Environment, Water Resources and Industry	110 778	491 496	602 274	549 801	52 473
Executive Management	26 383	1 250 000	1 276 383	1 126 095	150 288
Subtotal	**236 763**	**3 472 557**	**3 709 320**	**3 373 541**	**335 779**
Agency's Programmes	17 247 507	21 597 284	38 844 791	23 623 800	15 220 991
FAO: AGRIS	0	465 259	465 259	410 549	54 710
TOTAL Extrabudgetary	17 247 507	22 062 543	39 310 050	24 034 349	15 275 701

Note: In addition to the above Extrabudgetary Programme Fund, Member States and UNDP provided $4.1 million in 1999 for technical co-operation projects under the Technical Co-operation Extrabudgetary Fund.

Table A3. **DISBURSEMENTS BY AGENCY PROGRAMME AND REGION IN 1999**
(summary of all areas, in thousands of dollars)

Programme	Africa	Latin America	East Asia and the Pacific	West Asia	Europe	Inter-regional	Total
Nuclear Power	186.1	319.8	328.0	264.7	846.2	687.8	2 632.6
Nuclear Fuel Cycle and Waste Technology	432.0	120.2	486.7	383.5	983.0	456.0	2 861.4
Comparative Assessment of Energy Sources	62.9	32.0	139.9	0.0	266.4	102.2	603.4
Food and Agriculture	4 966.7	1 684.6	1 679.4	1 113.7	447.8	523.0	10 415.2
Human Health	3 836.4	3 071.3	2 461.7	868.8	2 724.7	307.2	13 270.1
Marine Environment, Water Resources and Industry	1 698.2	1 520.9	2 467.6	1 065.0	3 018.5	0.9	9 771.1
Physical and Chemical Sciences	1 464.0	1 281.7	1 110.2	1 408.4	2 758.8	109.1	8 132.2
Nuclear Safety	127.8	199.5	860.8	156.9	1 977.9	129.1	3 452.0
Radiation Safety	1 100.6	1 626.3	1 550.6	1 134.4	1 894.1	31.0	7 337.0
Radioactive Waste Safety	290.8	112.5	74.0	34.5	506.9	0.0	1 018.7
Co-ordination of Safety Activities	185.1	184.8	91.8	79.2	90.9	56.6	688.4
Safeguards	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Security of Material	0.0	0.0	0.0	0.0	309.7	0.0	309.7
Management of Technical Co-operation for Development	413.3	633.3	1,080.0	200.1	260.2	502.1	3 089.0
Management, Co-ordination and Support							
Legal Activities, External Relations and Public Information	0.0	4.9	0.0	0.0	186.0	0.0	190.9
General Services	0.0	0.0	5.7	0.0	0.0	0.0	5.7
Information Management and Support Services	26.2	89.2	31.9	12.5	45.5	39.2	244.5
TOTAL	14 790.1	10 881.0	12 368.3	6 721.7	16 316.6	2 944.2	64 021.9

Table A4. **INTERNATIONAL PEER REVIEW SERVICE (IPERS) ON PSA REVIEWS, 1999**

Review type	Location, Country	Nuclear Power Plant
Pre-IPERS Level 1 PSA	Karachi, Pakistan	KANUPP CANDU
Low power and shutdown PSA	Budapest/Paks, Hungary	Paks WWER 440/213
Low power and shutdown PSA	Piestany, Slovakia	Bohunice V2 WWER 440/213

Table A5. **ENGINEERING SAFETY REVIEW SERVICE (ESRS) MISSIONS RELATED TO SITE AND EXTERNAL HAZARDS, 1999**

Country	Site/plant	Service
Korea, Rep. of		AMAT
Romania	Cernavoda	CMRS and EIPSA
China	Lianyunggang	DSRS and W
Islamic Rep. of Iran	Bushehr	SSRS and DSRS
Bulgaria	Kozloduy	SSRS
China	CEFR	DSRS
China	Quinshan	3 SWSRS
Armenia	Medzamor	SSRS and DSRS
Turkey	Akkuyu	SSRS
Turkey	Istanbul	SSRS of an RR
Kazakhstan	Balkash	SSRS and W
Pakistan	Chashma	DSRS and FSRS
Pakistan	KANUPP	AMAT
Slovenia	Krško	DSRS
Slovakia	Bohunice	SSRS
Morocco	Mamoora	SSRS of an RR
Dem. Rep. of the Congo	Kinshasa	SSRS of an RR
Ukraine	South Ukraine	DSRS

CEFR: Chinese Experimental Fast Reactor; **DSRS**: Design Safety Review Service; **SSRS**: Seismic (or Site) Safety Review Service; **FSRS**: Fire Safety Review Service; **SWSRS**: Software Safety Review Service; **CMRS**: Configuration Management Review Service; **AMAT**: Ageing Management Advisory Team; **EIPSA**: External and internal event PSA; **W**: workshop; **RR**: research reactor

Table A6. **Y2K RELATED SAFETY MISSIONS TO NUCLEAR POWER PLANTS**

Plant	Country
Chernobyl	Ukraine
Chernobyl	Ukraine
Qinshan	China
Bohunice	Slovakia
Zaporozhe	Ukraine
Qinshan	China
Guangdong	China
Zaporozhe	Ukraine
South Ukraine	Ukraine
South Ukraine	Ukraine
Kozloduy	Bulgaria
Armenia	Armenia
Chernobyl	Ukraine
Balakovo	Russian Federation
Krško	Slovenia
Armenia	Armenia
Zaporozhe	Ukraine
Qinshan	China
Ignalina	Lithuania
Angra	Brazil

Table A7. **OPERATIONAL SAFETY REVIEW TEAM (OSART) MISSIONS, 1999**

Type	Location/plant	Plant type	Country
OSART	Kozloduy	WWER	Bulgaria
Follow-up OSART	Qinshan	PWR	China
Preparatory Visit	North Anna	PWR	USA
Pre-OSART	Chashma	PWR	Pakistan
Preparatory Visit	Temelin	WWER	Czech Republic
OSART	Bugey	PWR	France
Follow-up OSART	Embalse	PHWR	Argentina
Follow-up OSART	Palual	PWR	France
Preparatory Visit	Belleville	PWR	France
Follow-up OSART	Yonggwang	PWR	Rep. of Korea
Preparatory Visit	Mühleberg	BWR	Switzerland
OSART	Gösgen	PWR	Switzerland

Table A8. **SAFETY CULTURE SERVICE MISSIONS, 1999**

Type	Country	Location/ plant
Safety culture enhancement	Brazil	Angra
Peer review of self-assessment	Brazil	Angra
Management of safety culture workshop	Bulgaria	Ledenika

Table A9. **ASSESSMENT OF SAFETY SIGNIFICANT EVENTS TEAM (ASSET) SERVICES AND OPERATING EXPERIENCE REVIEW ACTIVITY, 1999**

Type	Country	Location/nuclear power plant
S_A	Slovakia	Bratislava
S	Armenia	Metsamor
Z	Ukraine	South Ukraine
S_A	India	Kakrapar

S: ASSET seminar to present guidance for plant self-assessment; **S_A**: workshop on analysis of the root causes of events; **Z**: peer review of self-assessment of plant operational events.

Table A10. **INTERNATIONAL REGULATORY REVIEW TEAM (IRRT) MISSIONS, 1999**

Type of mission	Country
Pre-IRRT	Indonesia
Pre-IRRT	Viet Nam
Full scope IRRT	Slovenia

Table A11. **INTEGRATED SAFETY ASSESSMENT OF RESEARCH REACTORS (INSARR) MISSIONS, 1999**

Type	Location/nuclear power plant	Country
Review of operational safety	BR-II	Belgium
Review of operational safety	Otaniemi	Finland

Table A12. **INTERNATIONAL NUCLEAR EVENT SCALE (INES) RATINGS REPORTED, 1999**

Level	Description	Number reported
Below scale	Deviation	2
1	Anomaly	4
2	Incident	14
3	Serious incident	3
4	Accident	1 (Tokaimura accident)

Table A13. **NUMBER OF STATES HAVING SIGNIFICANT NUCLEAR ACTIVITIES AT THE END OF 1997, 1998 AND 1999**

	Number of States		
	1997	**1998**	**1999**
States with safeguards applied under NPT or NPT/Tlatelolco agreements	56[a]	58[a]	60
States with safeguards applied under Tlatelolco agreements	2	1	1
States with safeguards applied pursuant to other comprehensive safeguards agreements	1	0	0
States with safeguards applied under INFCIRC/66/Rev.2-type agreements[b]	4	4	4
Nuclear weapon States with safeguards applied under voluntary offer agreements	5	5	5
States without any safeguards agreement in force	1	1	1
Total number of States with significant nuclear activities[c]	69	69	71

[a] This excludes Iraq, where safeguards activities continued to be subsumed under activities carried out pursuant to United Nations Security Council Resolution 687.

[b] Some States with INFCIRC/66/Rev.2-type agreements under which the application of safeguards has not yet been suspended, although NPT or other comprehensive safeguards agreements have entered into force, are listed under NPT agreements only. Nuclear weapon States with INFCIRC/66/Rev.2-type agreements in force are not included. Safeguards are also applied to nuclear installations in Taiwan, China.

[c] According to information available to the Agency for the year in question.

Table A14. **SITUATION ON 31 DECEMBER 1999 WITH RESPECT TO THE CONCLUSION OF SAFEGUARDS AGREEMENTS BETWEEN THE AGENCY AND NON-NUCLEAR-WEAPON STATES IN CONNECTION WITH NPT**

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Afghanistan	4 February 1970	In force: 20 February 1978	257
Albania[b]	12 September 1990		
Algeria	12 January 1995	In force: 7 January 1997	531
Andorra	7 June 1996		
Angola	14 October 1996		
Antigua and Barbuda[c]	27 November 1968	In force: 9 September 1996	528
Argentina[d]	10 February 1995	In force: 18 March 1997	435/Mod.1
Armenia	15 July 1993	In force: 5 May 1994	455
Australia	23 January 1973	In force: 10 July 1974	217
Austria[e]	27 June 1969	Accession: 31 July 1996	193
Azerbaijan	22 September 1992	In force: 29 April 1999	580
Bahamas[c]	10 July 1973	In force: 12 September 1997	544
Bahrain	3 November 1988		
Bangladesh	31 August 1979	In force: 11 June 1982	301
Barbados[c]	21 February 1980	In force: 14 August 1996	527
Belarus	22 July 1993	In force: 2 August 1995	495
Belgium	2 May 1975	In force: 21 February 1977	193
Belize[f]	9 August 1985	In force: 21 January 1997	532
Benin	31 October 1972		
Bhutan	23 May 1985	In force: 24 October 1989	371
Bolivia[c]	26 May 1970	In force: 6 February 1995	465
Bosnia and Herzegovina[g]	15 August 1994	In force: 28 December 1973	204
Botswana	28 April 1969		
Brazil[d]	18 September 1998	In force: 20 September 1999	435/Mod.3
Brunei Darussalam	26 March 1985	In force: 4 November 1987	365
Bulgaria	5 September 1969	In force: 29 February 1972	178
Burkina Faso	3 March 1970		
Burundi	19 March 1971		
Cambodia	2 June 1972	In force: 17 December 1999	
Cameroon	8 January 1969	Signed: 21 May 1992	
Canada	8 January 1969	In force: 21 February 1972	164
Cape Verde	24 October 1979		
Central African Republic	25 October 1970		
Chad	10 March 1971		
Chile[h]	25 May 1995	In force: 9 September 1996	476/Mod.1
Colombia[i]	8 April 1986		
Comoros	4 October 1995		
Congo	23 October 1978		
Costa Rica[c]	3 March 1970	In force: 22 November 1979	278
Côte d'Ivoire	6 March 1973	In force: 8 September 1983	309
Croatia	29 June 1992	In force: 19 January 1995	463
Cyprus	10 February 1970	In force: 26 January 1973	189
Czech Republic[j]	1 January 1993	In force: 11 September 1997	541
Democratic People's Republic of Korea	12 December 1985	In force: 10 April 1992	403

Table A14. **SITUATION ON 31 DECEMBER 1999 (cont.)**

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Democratic Republic of the Congo	4 August 1970	In force: 9 November 1972	183
Denmark[k]	3 January 1969	In force: 21 February 1977	193
Djibouti	16 October 1996		
Dominica[f]	10 August 1984	In force: 3 May 1996	513
Dominican Republic[c]	24 July 1971	In force: 11 October 1973	201
Ecuador[c]	7 March 1969	In force: 10 March 1975	231
Egypt	26 February 1981	In force: 30 June 1982	302
El Salvador[c]	11 July 1972	In force: 22 April 1975	232
Equatorial Guinea	1 November 1984	Approved: 13 June 1986	
Eritrea	16 March 1995		
Estonia	7 January 1992	In force: 24 November 1997	547
Ethiopia	5 February 1970	In force: 2 December 1977	261
Fiji	14 July 1972	In force: 22 March 1973	192
Finland[l]	5 February 1969	Accession: 1 October 1995	193
Gabon	19 February 1974	Signed: 3 December 1979	
Gambia	12 May 1975	In force: 8 August 1978	277
Georgia	7 March 1994	Signed: 29 September 1997	
Germany[m]	2 May 1975	In force: 21 February 1977	193
Ghana	4 May 1970	In force: 17 February 1975	226
Greece[n]	11 March 1970	Accession: 17 December 1981	193
Grenada[c]	19 August 1974	In force: 23 July 1996	525
Guatemala[c]	22 September 1970	In force: 1 February 1982	299
Guinea	29 April 1985		
Guinea-Bissau	20 August 1976		
Guyana[c]	19 October 1993	In force: 23 May 1997	543
Haiti[c]	2 June 1970	Signed: 6 January 1975	
Holy See	25 February 1971	In force: 1 August 1972	187
Honduras[c]	16 May 1973	In force: 18 April 1975	235
Hungary	27 May 1969	In force: 30 March 1972	174
Iceland	18 July 1969	In force: 16 October 1974	215
Indonesia	12 July 1979	In force: 14 July 1980	283
Iran, Islamic Republic of	2 February 1970	In force: 15 May 1974	214
Iraq	29 October 1969	In force: 29 February 1972	172
Ireland	1 July 1968	In force: 21 February 1977	193
Italy	2 May 1975	In force: 21 February 1977	193
Jamaica[c]	5 March 1970	In force: 6 November 1978	265
Japan	8 June 1976	In force: 2 December 1977	255
Jordan	11 February 1970	In force: 21 February 1978	258
Kazakhstan	14 February 1994	In force: 11 August 1995	504
Kenya	11 June 1970		
Kiribati	18 April 1985	In force: 19 December 1990	390
Korea, Republic of	23 April 1975	In force: 14 November 1975	236
Kuwait	17 November 1989	Signed: 10 May 1999	
Kyrgyzstan	5 July 1994	Signed: 18 March 1998	

Table A14. **SITUATION ON 31 DECEMBER 1999 (cont.)**

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Lao People's Democratic Republic	20 February 1970	Signed: 22 November 1991	
Latvia	31 January 1992	In force: 21 December 1993	434
Lebanon	15 July 1970	In force: 5 March 1973	191
Lesotho	20 May 1970	In force: 12 June 1973	199
Liberia	5 March 1970		
Libyan Arab Jamahiriya	26 May 1975	In force: 8 July 1980	282
Liechtenstein	20 April 1978	In force: 4 October 1979	275
Lithuania	23 September 1991	In force: 15 October 1992	413
Luxembourg	2 May 1975	In force: 21 February 1977	193
Madagascar	8 October 1970	In force: 14 June 1973	200
Malawi	18 February 1986	In force: 3 August 1992	409
Malaysia	5 March 1970	In force: 29 February 1972	182
Maldives	7 April 1970	In force: 2 October 1977	253
Mali	10 February 1970		
Malta	6 February 1970	In force: 13 November 1990	387
Marshall Islands	30 January 1995		
Mauritania	26 October 1993		
Mauritius	8 April 1969	In force: 31 January 1973	190
Mexico[c]	21 January 1969	In force: 14 September 1973	197
Micronesia, Federated States of	14 April 1995		
Monaco	13 March 1995	In force: 13 June 1996	524
Mongolia	14 May 1969	In force: 5 September 1972	188
Morocco	27 November 1970	In force: 18 February 1975	228
Mozambique	4 September 1990		
Myanmar	2 December 1992	In force: 20 April 1995	477
Namibia	2 October 1992	In force: 15 April 1998	551
Nauru	7 June 1982	In force: 13 April 1984	317
Nepal	5 January 1970	In force: 22 June 1972	186
Netherlands[o]	2 May 1975	In force: 21 February 1977	193
New Zealand[p]	10 September 1969	In force: 29 February 1972	185
Nicaragua[c]	6 March 1973	In force: 29 December 1976	246
Niger	9 October 1992		
Nigeria	27 September 1968	In force: 29 February 1988	358
Norway	5 February 1969	In force: 1 March 1972	177
Oman	23 January 1997	Approved: 20 September 1999	
Palau, Republic of	14 April 1995		
Panama[c,q]	13 January 1977	Signed : 22 December 1988	
Papua New Guinea	13 January 1982	In force: 13 October 1983	312
Paraguay[c]	4 February 1970	In force: 20 March 1979	279
Peru[c]	3 March 1970	In force: 1 August 1979	273
Philippines	5 October 1972	In force: 16 October 1974	216
Poland	12 June 1969	In force: 11 October 1972	179
Portugal[r]	15 December 1977	Accession: 1 July 1986	193
Qatar	3 April 1989		

Table A14. **SITUATION ON 31 DECEMBER 1999 (cont.)**

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Republic of Moldova	11 October 1994	Signed: 14 June 1996	
Romania	4 February 1970	In force: 27 October 1972	180
Rwanda	20 May 1975		
St. Kitts and Nevis[f]	22 March 1993	In force: 7 May 1996	514
St. Lucia[f]	28 December 1979	In force: 2 February 1990	379
St. Vincent and the Grenadines[f]	6 November 1984	In force: 8 January 1992	400
Samoa	17 March 1975	In force: 22 January 1979	268
San Marino	10 August 1970	In force: 21 September 1998	575
São Tome and Principe	20 July 1983		
Saudi Arabia	3 October 1988		
Senegal	17 December 1970	In force: 14 January 1980	276
Seychelles	12 March 1985		
Sierra Leone	26 February 1975	Signed: 10 November 1977	
Singapore	10 March 1976	In force: 18 October 1977	259
Slovakia[s]	1 January 1993	In force: 3 March 1972	173
Slovenia	7 April 1992	In force: 1 August 1997	538
Solomon Islands	17 June 1981	In force: 17 June 1993	420
Somalia	5 March 1970		
South Africa	10 July 1991	In force: 16 September 1991	394
Spain	5 November 1987	Accession: 5 April 1989	193
Sri Lanka	5 March 1979	In force: 6 August 1984	320
Sudan	31 October 1973	In force: 7 January 1977	245
Suriname[c]	30 June 1976	In force: 2 February 1979	269
Swaziland	11 December 1969	In force: 28 July 1975	227
Sweden[t]	9 January 1970	Accession: 1 June 1995	193
Switzerland	9 March 1977	In force: 6 September 1978	264
Syrian Arab Republic	24 September 1969	In force: 18 May 1992	407
Tajikistan	17 January 1997		
Thailand	7 December 1972	In force: 16 May 1974	241
The Former Yugoslav Republic of Macedonia	30 March 1995		
Togo	26 February 1970	Signed: 29 November 1990	
Tonga	7 July 1971	In force: 18 November 1993	426
Trinidad and Tobago[c]	30 October 1986	In force: 4 November 1992	414
Tunisia	26 February 1970	In force: 13 March 1990	381
Turkey	17 April 1980	In force: 1 September 1981	295
Turkmenistan	29 September 1994		
Tuvalu	19 January 1979	In force: 15 March 1991	391
Uganda	20 October 1982		
Ukraine	5 December 1994	In force: 22 January 1998	550
United Arab Emirates	26 September 1995		
United Republic of Tanzania	31 May 1991	Signed: 26 August 1992	
Uruguay[c]	31 August 1970	In force: 17 September 1976	157
Uzbekistan	7 May 1992	In force: 8 October 1994	508
Vanuatu	24 August 1995		
Venezuela[c]	25 September 1975	In force: 11 March 1982	300

Table A14. **SITUATION ON 31 DECEMBER 1999 (cont.)**

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Viet Nam	14 June 1982	In force: 23 February 1990	376
Yemen, Republic of	1 June 1979		
Yugoslavia[u], Federal Republic of	4 March 1970	In force: 28 December 1973	204
Zambia	15 May 1991	In force: 22 September 1994	456
Zimbabwe	26 September 1991	In force: 26 June 1995	483

[a] The information in columns (1) and (2) was provided to the Agency by depositary governments of NPT, and an entry in column (1) does not imply the expression of any opinion on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers. The table does not contain information relating to the participation of Taiwan, China, in NPT.

[b] A sui generis comprehensive safeguards agreement with Albania entered into force on 25 March 1988 (INFCIRC/359).

[c] The relevant safeguards agreement refers to both NPT and the Treaty of Tlatelolco.

[d] An exchange of letters has taken place between this State and the Agency confirming that the safeguards agreement concluded between Argentina, Brazil, ABACC and the Agency for the application of safeguards which entered into force on 4 March 1994 (INFCIRC/435) satisfies the requirements of this State under Article III of the NPT to conclude a safeguards agreement with the Agency. The exchange of letters entered into force on the date of approval by the Board of Governors.

[e] The application of safeguards in Austria under the NPT safeguards agreement INFCIRC/156, in force since 23 July 1972, was suspended on 31 July 1996, on which date the agreement of 5 April 1973 (INFCIRC/193) between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency, to which Austria had acceded, entered into force for Austria.

[f] An exchange of letters has taken place between this State and the Agency confirming that the NPT safeguards agreement concluded with the State satisfies the obligations of the State under Article 13 of the Treaty of Tlatelolco to conclude a safeguards agreement with the Agency.

[g] The NPT safeguards agreement concluded with the Socialist Federal Republic of Yugoslavia (INFCIRC/204), which entered into force on 28 December 1973, continues to be applied in Bosnia and Herzegovina to the extent relevant to the territory of Bosnia and Herzegovina.

[h] An exchange of letters has taken place between this State and the Agency confirming that the safeguards agreement concluded with the State pursuant to the Treaty of Tlatelolco satisfies the requirements of the obligations of the State under Article III of the NPT to conclude a safeguards agreement with the Agency. The exchange of letters entered into force on the date of approval by the Board of Governors.

[i] A comprehensive safeguards agreement with Colombia concluded pursuant to the Treaty of Tlatelolco entered into force on 22 December 1982 (INFCIRC/306).

[j] The NPT safeguards agreement concluded with the Czechoslovak Socialist Republic (INFCIRC/173), which entered into force on 3 March 1972, continued to be applied in the Czech Republic to the extent relevant to the territory of the Czech Republic until 11 September 1997, on which date the NPT safeguards agreement concluded with the Czech Republic entered into force.

[k] The NPT safeguards agreement with Denmark (INFCIRC/176), in force since 1 March 1972, has been replaced by the agreement of 5 April 1973 between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency (INFCIRC/193) but still applies to the Faroe Islands. Upon Greenland's secession from EURATOM as of 31 January 1985, the Agreement between the Agency and Denmark (INFCIRC/176) re-entered into force as to Greenland.

[l] The application of safeguards in Finland under the NPT safeguards agreement INFCIRC/155, in force since 9 February 1972, was suspended on 1 October 1995, on which date the agreement of 5 April 1973 (INFCIRC/193) between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency, to which Finland had acceded, entered into force for Finland.

[m] The NPT safeguards agreement of 7 March 1972 concluded with the German Democratic Republic (INFCIRC/181) is no longer in force with effect from 3 October 1990, on which date the German Democratic Republic acceded to the Federal Republic of Germany.

[n] The application of safeguards in Greece under the NPT safeguards agreement INFCIRC/166, provisionally in force since 1 March 1972, was suspended on 17 December 1981, on which date Greece acceded to the agreement of 5 April 1973 (INFCIRC/193) between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency.

[o] An agreement had also been concluded in respect of the Netherlands Antilles (INFCIRC/229). This agreement entered into force on 5 June 1975.

[p] The NPT safeguards agreement with New Zealand (INFCIRC/185) also applies to Cook Islands, Niue and Tokelau.

[q] A comprehensive safeguards agreement with Panama concluded pursuant to the Treaty of Tlatelolco entered into force on 23 March 1984 (INFCIRC/316).

[r] The application of safeguards in Portugal under the NPT safeguards agreement INFCIRC/272, in force since 14 June 1979, was suspended on 1 July 1986, on which date Portugal acceded to the agreement of 5 April 1973 (INFCIRC/193) between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency.

[s] The NPT safeguards agreement concluded with the Czechoslovak Socialist Republic (INFCIRC/173), which entered into force on 3 March 1972, continues to be applied in Slovakia to the extent relevant to the territory of Slovakia. A new NPT safeguards agreement concluded with Slovakia was approved by the Board of Governors on 14 September 1998.

[t] The application of safeguards in Sweden under the NPT safeguards agreement INFCIRC/234, in force since 14 April 1975, was suspended on 1 June 1995, on which date the agreement of 5 April 1973 (INFCIRC/193) between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency, to which Sweden had acceded, entered into force for Sweden.

[u] The NPT safeguards agreement concluded with the Socialist Federal Republic of Yugoslavia (INFCIRC/204), which entered into force on 28 December 1973, continues to be applied in the Federal Republic of Yugoslavia to the extent relevant to the territory of the Federal Republic of Yugoslavia.

Table A15. **SITUATION ON 31 DECEMBER 1999 WITH RESPECT TO THE CONCLUSION OF SAFEGUARDS AGREEMENTS BETWEEN THE AGENCY AND STATES PARTY TO THE TREATY OF TLATELOLCO[a]**

States party to the Treaty of Tlatelolco (1)	Date of becoming a party to the Treaty of Tlatelolco (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Antigua and Barbuda[b]	11 October 1983	In force: 9 September 1996	528
Argentina[c]	18 January 1994	In force: 18 March 1997	435/Mod.1
Bahamas[b]	26 April 1977	In force: 12 September 1997	544
Barbados[b]	25 April 1969	In force: 14 August 1996	527
Belize[d]	4 November 1994	In force: 18 March 1997	532/Mod.1
Bolivia[b]	18 February 1969	In force: 6 February 1995	465
Brazil[c]	30 May 1994	In force: 10 June 1997	435/Mod.2
Chile	18 January 1994	In force: 5 April 1995	476
Colombia	6 September 1972	In force: 22 December 1982	306
Costa Rica[b]	25 August 1969	In force: 22 November 1979	278
Dominica[d]	25 August 1993	In force: 10 June 1997	513/Mod.1
Dominican Republic[b]	14 June 1968	In force: 11 October 1973	201
Ecuador[b]	11 February 1969	In force: 10 March 1975	231
El Salvador[b]	22 April 1968	In force: 22 April 1975	232
Grenada[b]	20 June 1975	In force: 23 July 1996	525
Guatemala[b]	6 February 1970	In force: 1 February 1982	299
Guyana[b]	6 May 1996	In force: 23 May 1997	543
Haiti[b]	23 May 1969	Signed: 6 January 1975	
Honduras[b]	23 September 1968	In force: 18 April 1975	235
Jamaica[b]	26 June 1969	In force: 6 November 1978	265
Mexico[b,e]	20 September 1967	In force: 14 September 1973	197
Nicaragua[b]	24 October 1968	In force: 29 December 1976	246
Panama[f]	11 June 1971	In force: 23 March 1984	316
Paraguay[b]	19 March 1969	In force: 20 March 1979	279
Peru[b]	4 March 1969	In force: 1 August 1979	273
St. Kitts and Nevis[d]	14 February 1997	In force: 18 March 1997	514/Mod.1
St. Lucia[d]	2 June 1995	In force: 12 June 1996	379/Mod.1
St. Vincent and the Grenadines[d]	11 May 1992	In force: 18 March 1997	400/Mod.1
Suriname[b]	10 June 1977	In force: 2 February 1979	269
Trinidad and Tobago[b]	27 June 1975	In force: 4 November 1992	414
Uruguay[b]	20 August 1968	In force: 17 September 1976	157
Venezuela[b]	23 March 1970	In force: 11 March 1982	300

In addition, there are the following safeguards agreements with States party to Additional Protocol I to the Treaty[g]:

France	Approved by the Board, June 1998	
Netherlands[b]	In force: 5 June 1975	229
United Kingdom	Approved by the Board, Sep.1992	
United States of America	In force: 6 April 1989	366

[a] The information in columns (1) and (2) was provided by Mexico as depositary of the Treaty of Tlatelolco. In addition to the States listed in column (1), Cuba signed the Treaty on 25 March 1995.

[b] The relevant safeguards agreement refers to both the Treaty of Tlatelolco and the NPT.

[c] An exchange of letters has taken place between this State and the Agency confirming that the safeguards agreement concluded between Argentina, Brazil, ABACC and the Agency for the application of safeguards which entered into force on 4 March 1994 (INFCIRC/435) satisfies the requirements of this State under Article 13 of the Treaty of Tlatelolco to conclude a safeguards agreement with the Agency. The exchange of letters entered into force on the date of approval by the Board of Governors.

[d] An exchange of letters has taken place between this State and the Agency confirming that the NPT safeguards agreement concluded with the State satisfies the obligations of the State under Article 13 of the Treaty of Tlatelolco to conclude a safeguards agreement with the Agency. The exchange of letters entered into force on the date of approval by the Board of Governors.

[e] The application of safeguards under an agreement with Mexico in connection with the Treaty of Tlatelolco which entered into force on 6 September 1968 (INFCIRC/118) was suspended after the conclusion of an agreement with Mexico in connection with both the Treaty of Tlatelolco and NPT (INFCIRC/197).

[f] A safeguards agreement pursuant to both the Treaty of Tlatelolco and NPT has been concluded with Panama; the agreement has not yet entered into force.

[g] Additional Protocol I refers to States outside Latin America and the Caribbean which have de jure or de facto jurisdiction over territories which lie within the limits of the geographical zone established in the Treaty.

Table A16. **AGREEMENTS PROVIDING FOR SAFEGUARDS, OTHER THAN THOSE IN CONNECTION WITH NPT OR THE TREATY OF TLATELOLCO, APPROVED BY THE BOARD OF GOVERNORS AS OF 31 DECEMBER 1999[a]**

Party(ies)[b]	Subject	Entry into force	INFCIRC
(While the Agency is a party to each of the following agreements, only the State(s) party to them is (are) listed.)			
(i) Project agreements			
Argentina[c]	Siemens SUR-100	13 March 1970	143
	RAEP reactor	2 December 1964	62
Chile[d]	Herald reactor	19 December 1969	137
Colombia[d]	Fuel for research reactor	17 June 1994	460
Democratic Republic of the Congo[e]	TRICO reactor	27 June 1962	37
	Fuel for research reactor	20 September 1990	389
Finland[e]	FIR-1 reactor	30 December 1960	24
	FINN subcritical assembly	30 July 1963	53
Ghana[e]	Research reactor and fuel therefor	14 October 1994	468
Greece[e]	GRR-1 reactor	1 March 1972	163
Indonesia[e]	Additional core-load for TRIGA reactor	19 December 1969	136
	Supply of enriched uranium	15 January 1993	453
	Supply of enriched uranium	15 January 1993	454
Iran, Islamic Republic of[e]	UTRR reactor	10 May 1967	97
Jamaica[e]	Fuel for research reactor	25 January 1984	315
Japan[e]	JRR-3	24 March 1959	3
Malaysia[e]	TRIGA-II reactor	22 September 1980	287
Mexico[e]	TRIGA-III reactor	18 December 1963	52
	Siemens SUR-100	21 December 1971	162
	Laguna Verde Nuclear Power Plant	12 February 1974	203
Morocco[e]	Fuel for research reactor	2 December 1983	313
Nigeria[e]	Research reactor and fuel therefor	29 August 1996	526
Pakistan	PRR reactor	5 March 1962	34
	Booster rods for KANUPP	17 June 1968	116
Peru[e]	Research reactor and fuel therefor	9 May 1978	266
Philippines[e]	PRR-1 reactor	28 September 1966	88
Romania[e]	TRIGA reactor	30 March 1973	206
	Experimental fuel elements	1 July 1983	307
Slovenia[e]	TRIGA-II reactor	4 October 1961	32
	Krško Nuclear Power Plant	14 June 1974	213
Spain[e]	Coral-I reactor	23 June 1967	99
Syrian Arab Republic[e]	Miniature neutron source reactor and enriched uranium	18 May 1992	408
Thailand[e]	Fuel for research reactor	30 September 1986	342
Turkey[e]	Subcritical assembly	17 May 1974	212
Uruguay[e]	URR reactor	24 September 1965	67
Venezuela[e]	RV-1 reactor	7 November 1975	238
Viet Nam[e]	Fuel for research reactor	1 July 1983	308

Table A16. **AGREEMENTS PROVIDING FOR SAFEGUARDS (cont.)**

Party(ies)[b]	Subject	Entry into force	INFCIRC
(ii) Unilateral submissions			
Algeria	Nur research reactor[h]	9 April 1990	361
	Es Salam research reactor[h]	2 June 1992	401
Argentina	Atucha Power Reactor Facility [f]	3 October 1972	168
	Nuclear material [f]	23 October 1973	202
	Embalse Power Reactor Facility [f]	6 December 1974	224
	Equipment and nuclear material [f]	22 July 1977	250
	Nuclear material, material, equipment and facilities [f]	22 July 1977	251
	Atucha II Nuclear Power Plant [f]	15 July 1981	294
	Heavy water plant [f]	14 October 1981	296
	Heavy water [f]	14 October 1981	297
	Nuclear material [f]	8 July 1982	303
Chile	Nuclear material[g]	31 December 1974	256
	Nuclear material[g]	22 September 1982	304
	Nuclear material[g]	18 September 1987	350
Cuba	Nuclear power plant and nuclear material	5 May 1980	281
	Zero power nuclear reactor and fuel therefor	7 October 1983	311
Democratic People's Republic of Korea	Research reactor and nuclear material therefor[h]	20 July 1977	252
India	Nuclear material, material and facilities	17 November 1977	260
	Nuclear power station	27 September 1988	360
	Nuclear material	11 October 1989	374
	All nuclear material subject to safeguards under INFCIRC/154	1 March 1994	433*
Pakistan	Nuclear material	2 March 1977	248
	Miniature neutron source reactor	10 September 1991	393
	Nuclear power reactor	24 February 1993	418
Spain	Nuclear material[h]	18 June 1975	221
	Vandellos Nuclear Power Plant[h]	11 May 1981	292
	Specified nuclear facilities[h]	11 May 1981	291**
United Kingdom	Nuclear material	14 December 1972	175
Viet Nam	Research reactor and fuel therefor[h]	12 June 1981	293

* Amended in 1994 to cover nuclear material supplied for use in the Tarapur Atomic Power Station (TAPS) which material is required by the supplier to be subject to safeguards. The amendment entered into force on 12 September 1994 (INFCIRC/433/Mod.1).

** Amended in 1985 to cover specified nuclear facilities. The amendment entered into force on 8 November 1985 (INFCIRC/291/Mod.1/Corr.1).

Table A16. **AGREEMENTS PROVIDING FOR SAFEGUARDS (cont.)**

Party(ies)[b]	Subject	Entry into force	INFCIRC
(iii) Agreements concluded with nuclear weapon States on the basis of voluntary offers			
China	Nuclear material in facilities selected from list of facilities provided by China	18 September 1989	369
France	Nuclear material in facilities submitted to safeguards	12 September 1981	290
Russian Federation	Nuclear material in facilities selected from list of facilities provided by the Russian Federation	10 June 1985	327
United Kingdom	Nuclear material in facilities designated by the Agency	14 August 1978	263
United States of America	Nuclear material in facilities designated by the Agency	9 December 1980	288
(iv) Other comprehensive safeguards agreements			
Albania	All nuclear material and facilities	25 March 1988	359
Argentina/Brazil	All nuclear material in all nuclear activities	4 March 1994	435
(v) Other safeguards agreements			
Argentina[f]/United States of America[i]		25 July 1969	130
Austria[h]/United States of America		24 January 1970	152
Brazil[f]/Germany[h]		26 February 1976	237
Brazil[f]/United States of America[i]		31 October 1968	110
Colombia/United States of America		9 December 1970	144
India/Canada[h]		30 September 1971	211
Iran, Islamic Republic of [h]/United States of America		20 August 1969	127
Israel/United States of America		4 April 1975	249
Japan[h]/Canada[h]		20 June 1966	85
Japan[h]/France		22 September 1972	171
Korea, Republic of/United States of America		5 January 1968	111
Korea, Republic of [h]/France		22 September 1975	233
Pakistan/Canada		17 October 1969	135
Pakistan/France		18 March 1976	239
Philippines[h]/United States of America		19 July 1968	120
Portugal[h]/United States of America[i]		19 July 1969	131
South Africa/United States of America		26 July 1967	98
South Africa/France		5 January 1977	244
Spain/Germany[h]		29 September 1982	305
Spain[h]/United States of America[i]		9 December 1966	92
Spain/Canada[h]		10 February 1977	247
Sweden[h]/United States of America		1 March 1972	165
Switzerland[h]/United States of America[i]		28 February 1972	161
Turkey[h]/United States of America[i]		5 June 1969	123
Venezuela[h]/United States of America[i]		27 March 1968	122

(vi) The Agency also applies safeguards under two agreements (INFCIRC/133 and INFCIRC/158) to the nuclear facilities in Taiwan, China. Pursuant to the decision adopted by the Board of Governors on 9 December 1971 that the Government of the People's Republic of China is the only government which has the right to represent China in the Agency, the relations between the Agency and the authorities in Taiwan, China, are non-governmental. The agreements are implemented by the Agency on that basis.

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[a] Safeguards agreements pursuant to the South Pacific Nuclear Weapon Free Zone Treaty (Rarotonga Treaty) are not separately listed with this compilation since the Treaty requires that safeguards by the Agency will be applied pursuant to safeguards agreements equivalent in scope and effect to an agreement required in connection with the NPT on the basis of the material reproduced in INFCIRC/153 (Corrected). As of 31 December 1997, all 11 States Party to the Treaty (Australia, Cook Islands, Fiji, Kiribati, Nauru, New Zealand, Niue, Papua New Guinea, Solomon Islands, Tuvalu and Samoa) were covered by safeguards agreements concluded pursuant to NPT.

[b] An entry in this column does not imply the expression of any opinion whatsoever on the part of the Agency concerning the legal status of any country or territory or of its authorities or concerning the delimitation of its frontiers.

[c] Agency safeguards required by this project agreement are implemented pursuant to the comprehensive safeguards agreement concluded between Argentina, Brazil, the ABACC and the Agency (INFCIRC/435).

[d] Agency safeguards required by this project agreement are implemented pursuant to a safeguards agreement in connection with the Treaty of Tlatelolco covering the State indicated.

[e] Agency safeguards required by this (these) project agreement(s) are implemented pursuant to an agreement in connection with NPT covering the State indicated.

[f] Application of Agency safeguards under this agreement has been suspended in the State indicated. Safeguards are applied pursuant to the comprehensive safeguards agreement concluded between Argentina, Brazil, the ABACC and the Agency (INFCIRC/435).

[g] Application of Agency safeguards under this agreement has been suspended in the State indicated as the State has concluded an agreement in connection with the Treaty of Tlatelolco.

[h] Application of Agency safeguards under this agreement has been suspended in the State indicated as the State has concluded an agreement in connection with NPT.

[i] Application of Agency safeguards under this agreement has been suspended in the USA in order to comply with a provision of INFCIRC/288.

Table A17. **SITUATION ON 31 DECEMBER 1999 WITH RESPECT TO THE CONCLUSION OF PROTOCOLS ADDITIONAL TO SAFEGUARDS AGREEMENTS**

State	Status of the Protocol	INFCIRC
Armenia	signed 29 September 1997	
Australia	in force 12 December 1997	217/Add.1
Austria	signed 22 September 1998	
Belgium	signed 22 September 1998	
Bulgaria	signed24 September 1998	
Canada	signed 24 September 1998	
China	signed 31 December 1998	
Croatia	signed 22 September 1998	
Cuba	signed 15 October 1999	
Cyprus	signed 29 July 1999	
Czech Republic	signed 28 September 1999	
Denmark	signed 22 September 1998	
Ecuador	signed 1 October 1999	
Finland	signed 22 September 1998	
France	signed 22 September 1998	
Georgia	signed 29 September 1997	
Germany	signed 22 September 1998	
Ghana*	signed 12 June 1998	226/Add.1
Greece	signed 22 September 1998	
Holy See	in force 24 September 1998	187/Add.1
Hungary	signed 26 November 1998	
Indonesia	in force 29 September 1999	283/Add.1
Ireland	signed 22 September 1998	
Italy	signed 22 September 1998	
Japan	in force 16 December 1999	255/Add. 1
Jordan	in force 28 July 1998	258/Add.1
Korea, Republic of	signed 21 June 1999	
Lithuania	signed 11 March 1998	
Luxembourg	signed 22 September 1998	
Monaco	in force 30 September 1999	524/Add.1
Netherlands	signed 22 September 1998	
New Zealand	in force 24 September 1998	185/Add.1
Norway	signed 29 September 1999	
Peru	approved 10 December 1999	
Philippines	signed 30 September 1997	
Poland	signed 30 September 1997	
Portugal	signed 22 September 1998	
Romania	signed 11 June 1999	
Slovakia	signed 27 September 1999	
Slovenia	signed 26 November 1998	
Spain	signed 22 September 1998	
Sweden	signed 22 September 1998	
United Kingdom	signed 22 September 1998	
United States of America	signed 12 June 1998	
Uruguay	signed 29 September 1997	
Uzbekistan	in force 21 December 1998	508/Add.2

* Pending entry into force of the Protocol, it is applied provisionally in this State with effect from date of signature.

Table A18. **APPROXIMATE QUANTITIES OF MATERIAL SUBJECT TO AGENCY SAFEGUARDS AT THE END OF 1999**

Type of material	Quantity of material (t)			
	Comprehensive safeguards agreements[a]	INFCIRC/66[b]	Nuclear weapon States	Quantity in SQs
Nuclear material				
Plutonium[c] contained in irradiated fuel	503.7	26.4	78.9	76 117
Separated plutonium outside reactor cores	13.6	0.1	53.3	8 375
Recycled plutonium in fuel elements in reactor cores	7.6	0.4	0	994
HEU (equal to or greater than 20% ^{235}U)	11.1	0.1	10.0	596
LEU (less than 20% ^{235}U)	42 220	2 707	4 481	13 576
Source material[d] (natural or depleted uranium and thorium)	78 418	1 568	11 661	6 940
Non-nuclear material[e]				
Heavy water	0	509	0	25
Total significant quantities				106 598

[a] Covering safeguards agreements pursuant to NPT and/or Treaty of Tlatelolco and other comprehensive safeguards agreements.

[b] Excluding installations in nuclear weapon States; including installations in Taiwan, China.

[c] The quantity includes an estimated 92 t (11 540 SQ) of plutonium in irradiated fuel, which is not yet reported to the Agency under the reporting procedures agreed to (the non-reported plutonium is contained in irradiated fuel assemblies to which item accountancy and C/S measures are applied).

[d] This table does not include material within the terms of subparagraphs 34(a) and (b) of INFCIRC/153 (Corrected).

[e] Non-nuclear material subject to Agency safeguards under INFCIRC/66/Rev.2-type agreements.

Table A19. **NUMBER OF FACILITIES UNDER SAFEGUARDS OR CONTAINING SAFEGUARDED MATERIAL ON 31 DECEMBER 1999**

Facility type	Number of facilities (number of installations)			
	Comprehensive safeguards agreementsa	INFCIRC/66[b]	Nuclear weapon States	Total
Power reactors	184 (221)	11 (14)	1 (1)	196 (236)
Research reactors and critical assemblies	148 (160)	8 (8)	0 (0)	156 (168)
Conversion plants	12 (12)	1 (1)	0 (0)	13 (13)
Fuel fabrication plants	39 (41)	4 (4)	0 (0)	43 (45)
Reprocessing plants	5 (5)	1 (1)	0 (0)	6 (6)
Enrichment plants	11 (11)	0 (0)	3 (3)	14 (14)
Separate storage facilities	58 (59)	4 (4)	7 (8)	69 (71)
Other facilities	83 (94)	1 (1)	2 (2)	86 (97)
Subtotals	**540 (603)**	**30 (33)**	**13 (14)**	**583 (650)**
Other locations	313 (411)	3 (31)	0 (0)	316 (442)
Non-nuclear installations	0 (0)	1 (1)	0 (0)	1 (1)
Totals	853 (1014)	34 (65)	13 (14)	900 (1093)

[a] Covering safeguards agreements pursuant to NPT and/or Treaty of Tlatelolco and other comprehensive safeguards agreements.

[b] Excluding installations in nuclear weapon States; including installations in Taiwan, China.

Table A20. **FACILITIES UNDER AGENCY SAFEGUARDS OR CONTAINING SAFEGUARDED MATERIAL ON 31 DECEMBER 1999**

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Power reactors				
Argentina	Atucha NPP	1	Lima	—
	Embalse NPP	1	Embalse	—
Armenia	Armenia NPP	2	Medzamor	—
Belgium	BR3-Mol	1	Mol	x
	DOEL-1	2	Doel	x
	DOEL-3	1	Doel	x
	DOEL-4	1	Doel	x
	Tihange-1	1	Tihange	x
	Tihange-2	1	Tihange	x
	Tihange-3	1	Tihange	x
Brazil	Admiral Alvaro Alberto (Angra-1)	1	Angra dos Reis	x
	Admiral Alvaro Alberto (Angra-2)	1	Angra dos Reis	—
Bulgaria	Kozloduy-I	2	Kozloduy	x
	Kozloduy-II	2	Kozloduy	x
	Kozloduy-III	2	Kozloduy	x
Canada	Bruce A	4	Tiverton	x
	Bruce B	4	Tiverton	x
	Darlington N.G.S.	4	Bowmanville	x
	Gentilly-2	1	Gentilly	x
	Pickering G.S.	8	Pickering	x
	Point Lepreau G.S.	1	Point Lepreau	x
China	QSNPP	1	Hai Yan	x
Cuba	Juragua	2	Juragua	x
Czech Republic	EDU-1	2	Dukovany	x
	EDU-2	2	Dukovany	x
	Temelin	2	Temelin	—
Democratic People's Republic of Korea	Nyongbyon-1	1	Nyongbyon	—
Finland	Loviisa	2	Loviisa	—
	TVO I	1	Olkiluoto	—
	TVO II	1	Olkiluoto	—
Germany	AVR	1	Jülich	—
	KWG Grohnde	1	Grohnde	x
	GKN-2	1	Neckarwestheim	x
	RWE Biblis-A	1	Biblis	x
	RWE Biblis-B	1	Biblis	x
	KBR Brokdorf	1	Brokdorf	x
	KKB Brunsbüttel	1	Brunsbüttel	x
	KKE Emsland	1	Lingen	x
	KKG Grafenrheinfeld	1	Grafenrheinfeld	x
	KKI Isar-Ohu	1	Ohu bei Landshut	x
	KKI Isar-2	1	Essenbach	x
	KKK Krümmel	1	Geesthacht	x
	RWE Mühlheim-Kärlich	1	Mühlheim-Kärlich	x
	GKN Neckarwestheim	1	Neckarwestheim	x
	KWO Obrigheim	1	Obrigheim	x
	KKP Philippsburg-1	1	Philippsburg	x
	KKP Philippsburg-2	1	Philippsburg	x

Table A20. **FACILITIES UNDER AGENCY SAFEGUARDS (cont.)**

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Germany (cont.)	KRB II Gundremmingen B	1	Gundremmingen	x
	KRB II Gundremmingen C	1	Gundremmingen	x
	KKS Stade	1	Stade	x
	KKU Unterweser	1	Unterweser	x
	HKG-THTR 300	1	Hamm	—
	KKW Greifswald 1	2	Lubmin	—
	KKW Greifswald 2	2	Lubmin	—
	KKW Greifswald 3	1	Lubmin	—
	KKW Rheinsberg	1	Rheinsberg	x
Hungary	PAKS-I	2	Paks	x
	PAKS-II	2	Paks	x
India	RAPS	2	Rajasthan	x
	TAPS	2	Tarapur	x
Italy	ENEL-Latina	1	Borgo-Sabotino	x
	ENEL-Caorso	1	Caorso	x
	ENEL-Trino	1	Trino-Vercellese	x
Japan	Fugen	1	Tsuruga-shi, Fukui-ken	x
	Fukushima Dai-Ichi-1	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ichi-2	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ichi-3	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ichi-4	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ichi-5	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ichi-6	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ni-1	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ni-2	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ni-3	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ni-4	1	Futaba-gun, Fukushima-ken	x
	Genkai-1	1	Higashimatsura-gun, Saga-ken	x
	Genkai-2	1	Higashimatsura-gun, Saga-ken	x
	Genkai-3	1	Higashimatsura-gun, Saga-ken	x
	Genkai-4	1	Higashimatsura-gun, Saga-ken	x
	Hamaoka-1	1	Ogasa-gun, Shizuoka-ken	x
	Hamaoka-2	1	Ogasa-gun, Shizuoka-ken	x
	Hamaoka-3	1	Ogasa-gun, Shizuoka-ken	x
	Hamaoka-4	1	Ogasa-gun, Shizuoka-ken	x
	Ikata-1	1	Nishiuwa-gun, Ehime-ken	x
	Ikata-2	1	Nishiuwa-gun, Ehime-ken	x
	Ikata-3	1	Nishiuwa-gun, Ehime-ken	x
	Joyo	1	Higashi-gun, Ibaraki-ken	x
	Kashiwazaki-1	1	Kashiwazaki-shi, Niigata-ken	x
	Kashiwazaki-2	1	Kashiwazaki-shi, Niigata-ken	x
	Kashiwazaki-3	1	Kashiwazaki-shi, Niigata-ken	x
	Kashiwazaki-4	1	Kashiwazaki-shi, Niigata-ken	x
	Kashiwazaki-5	1	Kashiwazaki-shi, Niigata-ken	x
	Kashiwazaki-6	1	Kashiwazaki-shi, Niigata-ken	x
	Kashiwazaki-7	1	Kashiwazaki-shi, Niigata-ken	x
	Mihama-1	1	Mikata-gun, Fukui-ken	x
	Mihama-2	1	Mikata-gun, Fukui-ken	x
	Mihama-3	1	Mikata-gun, Fukui-ken	x
	Monju	1	Tsuruga-shi, Fukui-ken	x
	Ohi-1 and 2	2	Ohi-gun, Fukui-ken	x
	Ohi-3	1	Ohi-gun, Fukui-ken	x
	Ohi-4	1	Ohi-gun, Fukui-ken	x
	Onagawa-1	1	Oshika-gun, Miyaki-ken	x
	Onagawa-2	1	Oshika-gun, Miyaki-ken	x

Table A20. **FACILITIES UNDER AGENCY SAFEGUARDS (cont.)**

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Japan (cont.)	Sendai-1	1	Sendai-shi, Kagoshima-ken	x
	Sendai-2	1	Sendai-shi, Kagoshima-ken	x
	Shika	1	Hakui-gun, Ishikawa-ken	x
	Shimane-1	1	Yatsuka-gun, Shimane-ken	x
	Shimane-2	1	Yatsuka-gun, Shimane-ken	x
	Takahama-1	1	Ohi-gun, Fukui-ken	x
	Takahama-2	1	Ohi-gun, Fukui-ken	x
	Takahama-3	1	Ohi-gun, Fukui-ken	x
	Takahama-4	1	Ohi-gun, Fukui-ken	x
	Tokai-1	1	Tokai-Mura, Ibaraki-ken	x
	Tokai-2	1	Tokai-Mura, Ibaraki-ken	x
	Tomari-1	1	Furuu-gun, Hokkaido	x
	Tomari-2	1	Furuu-gun, Hokkaido	x
	Tsuruga-1	1	Tsuruga-shi, Fukui-ken	x
	Tsuruga-2	1	Tsuruga-shi, Fukui-ken	x
Kazakhstan	BN-350	1	Aktau	—
Korea, Republic of	Kori-1	1	Pusan	x
	Kori-2	1	Pusan	x
	Kori-3	1	Pusan	x
	Kori-4	1	Pusan	x
	Ulchin-1	1	Ulchin	x
	Ulchin-2	1	Ulchin	x
	Ulchin-3	1	Ulchin	x
	Ulchin-4	1	Ulchin	x
	Wolsong-1	1	Kyongju	x
	Wolsong-2	1	Kyongju	x
	Wolsong-3	1	Kyongju	x
	Wolsong-4	1	Kyongju	x
	Younggwang-1	1	Younggwang	x
	Younggwang-2	1	Younggwang	x
	Younggwang-3	1	Younggwang	x
	Younggwang-4	1	Younggwang	x
Lithuania	Ignalina NPP	2	Visaginas	x
Mexico	Laguna Verde 1	1	Alto Lucero	x
	Laguna Verde 2	1	Alto Lucero	x
Netherlands	Borssele	1	Borssele	x
	Dodewaard NPP	1	Dodewaard	x
Pakistan	KANUPP	1	Karachi	x
	Chasnupp-1	1	Kundian	—
Philippines	Bataan NPP	1	Morong, Bataan	x
Romania	Cernavoda-1	1	Cernavoda	—
Slovakia	A1	1	Bohunice	x
	EMO-1	2	Mochovce	—
	V-1	2	Bohunice	x
	V-2	2	Bohunice	x
Slovenia	Krško	1	Krško	x
South Africa	Koeberg-1	1	Cape Town	x
	Koeberg-2	1	Cape Town	x
Spain	Almaraz-1	1	Almaraz	x
	Almaraz-2	1	Almaraz	x

Table A20. **FACILITIES UNDER AGENCY SAFEGUARDS (cont.)**

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Spain (cont.)	Asco-1	1	Asco	x
	Asco-2	1	Asco	x
	Cofrentes	1	Cofrentes	x
	José Cabrera	1	Almonazid de Zorita	x
	Santa María de Garona	1	Santa María de Garona	x
	Trillo-1	1	Trillo	x
	Vandellos 1	1	Vandellos	—
	Vandellos 2	1	Vandellos	x
Sweden	Barsebäck 1	1	Malmö	—
	Barsebäck 2	1	Malmö	—
	Forsmark 1	1	Uppsala	—
	Forsmark 2	1	Uppsala	—
	Forsmark 3	1	Uppsala	—
	Oskarshamn 1	1	Oskarshamn	—
	Oskarshamn 2	1	Oskarshamn	—
	Oskarshamn 3	1	Oskarshamn	—
	Ringhals 1	1	Göteborg	—
	Ringhals 2	1	Göteborg	—
	Ringhals 3	1	Göteborg	—
	Ringhals 4	1	Göteborg	—
Switzerland	KKB Beznau I	1	Beznau	x
	KKB Beznau II	1	Beznau	x
	KKG Gösgen	1	Gösgen-Däniken	x
	KKL Leibstadt	1	Leibstadt	x
	KKM Mühleberg	1	Mühleberg	x
Ukraine	Chernobyl NPP	3	Chernobyl	—
	Khmelnitski 1	1	Neteshin	—
	Rovno 1 and 2	2	Kuznetsovsk	—
	Rovno 3	1	Kuznetsovsk	—
	South Ukraine 1	1	Yuzhnoukrainsk	—
	South Ukraine 2	1	Yuzhnoukrainsk	—
	South Ukraine 3	1	Yuzhnoukrainsk	—
	Zaporozhe 1	1	Energodar	—
	Zaporozhe 2	1	Energodar	—
	Zaporozhe 3	1	Energodar	—
	Zaporozhe 4	1	Energodar	—
	Zaporozhe 5	1	Energodar	—
	Zaporozhe 6	1	Energodar	—
Research reactors and critical assemblies				
Algeria	NUR Reactor	1	Algiers	—
	Es Salam research reactor	1	Ain Oussera	—
Argentina	Argentine reactor-1	1	Constituyentes	x
	Argentine reactor-3	1	Ezeiza	x
	Argentine reactor-4	1	Rosario	x
	Argentine reactor-6	1	Bariloche	x
	Argentine reactor-0	1	Córdoba	x
	Argentine reactor-8	1	Pilcaniyeu	x
Australia	HIFAR	1	Lucas Heights	x
	MOATA	1	Lucas Heights	x
Austria	ASTRA	1	Seibersdorf	—
	Siemens Argonaut Reactor	1	Graz	—
	Triga II	1	Vienna	—

Table A20. **FACILITIES UNDER AGENCY SAFEGUARDS (cont.)**

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Bangladesh	At. Energy Res. Est.	1	Dhaka	x
Belarus	Sosny	1	Minsk	—
Belgium	BR1-CEN	1	Mol	x
	BR2-CEN-BRO2	2	Mol	x
	CEN-Venus	1	Mol	x
	Thetis	1	Gent	x
Brazil	IEA-R1	1	São Paulo	—
	RIEN-1 Argonaut RR	1	Rio de Janeiro	x
	IPR-RI-CDTN	1	Belo Horizonte	x
	IPEN Critical assembly	1	São Paulo	x
Bulgaria	IRT-2000	1	Sofia	x
Canada	Biology, Chemistry, Physics	2	Chalk River	x
	McMaster	1	Hamilton	x
	NRU	1	Chalk River	x
	NRX	1	Chalk River	x
	Slowpoke-AECL	1	Ottawa	x
	Slowpoke-Dalhousie Univ.	1	Halifax	x
	Slowpoke-Ecole Polytechnique	1	Montreal	x
	Slowpoke-Kingston	1	Kingston	x
	Slowpoke-Saskatchewan	1	Saskatoon	x
	Slowpoke-Univ. of Toronto	1	Toronto	x
	Slowpoke-Univ. of Alberta	1	Edmonton	x
Chile	La Reina	1	Santiago	x
	Lo Aguirre	1	Santiago	x
Colombia	IAN-R1	1	Bogotá	x
Czech Republic	LR-0	1	Řež	x
	Univ. Training Reactor VR-1P	1	Prague	x
	VVR-S	1	Řež	x
Democratic People's Republic of Korea	Critical Assembly	1	Bungang-Ri, Nyongbyon	x
	IRT	1	Bungang-Ri, Nyongbyon	x
Democratic Republic of the Congo	Triga II	1	Kinshasa	x
Denmark	DR-1	1	Roskilde	x
	DR-3	1	Roskilde	x
Egypt	RR-I	1	Inshas	x
	MPR	1	Inshas	—
Estonia	Paldiski reactor	1	Paldiski	—
Finland	FIR 1	1	Otaniemi	—
Germany	BER-2	1	Berlin	x
	FH-Furtwangen	1	Furtwangen	x
	FRF-2	1	Frankfurt	x
	FRM	1	Garching	x
	GKSS-FRG1&FRG2	2	Geesthacht	x
	KFA-FRJ2	1	Jülich	x
	SUR 100	1	Hannover	x
	SUR 100	1	Kiel	x
	SUR 100	1	Hamburg	x

Table A20. **FACILITIES UNDER AGENCY SAFEGUARDS (cont.)**

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Germany (cont.)	SUR 100	1	Ulm	x
	SUR 100	1	Stuttgart	x
	SUR 100	1	Berlin	x
	SUR 100	1	Aachen	x
	Tech. Univ. AKR	1	Dresden	x
	Tech. Hochschule ZLR	1	Zittau	x
	Triga	1	Mainz	x
	MHH-Triga	1	Hannover	x
	DKFZ-Triga	1	Heidelberg	x
	VKT research reactor	1	Rossendorf	x
Ghana	GHARR-1	1	Legon-Accra	x
Greece	GRR-1	1	Attiki	x
Hungary	Training reactor	1	Budapest	x
	WWR-S M 10	1	Budapest	x
Indonesia	PPNY	1	Yogyakarta	x
	RSG-GAS	1	Serpong	x
	PPTN	1	Bandung	x
Iran, Islamic Republic of	TRR	1	Tehran	x
	HWZPR	1	Esfahan	x
	MNSR	1	Esfahan	x
Israel	IRR-1	1	Soreq	x
Italy	AGN-201	1	Palermo	x
	Poltec.	1	Milan	x
	RTS-1	1	San Piero a Grado	x
	TAPIRO	1	Santa Maria di Galeria	x
	Triga-RC1	1	Santa Maria di Galeria	x
	Triga-2	1	Pavia	x
Jamaica	Centre for Nucl. Sciences	1	Kingston	x
Japan	DCA	1	Oarai-machi, Ibaraki-ken	x
	FCA	1	Tokai-Mura, Ibaraki-ken	x
	HTR	1	Kawasaki-shi, Kanagawa-ken	x
	HTTR	1	Higashi-gun, Ibaraki-ken	x
	JMTR	1	Higashi-gun, Ibaraki-ken	x
	JMTRCA	1	Higashi-gun, Ibaraki-ken	x
	JRR-2	1	Tokai-Mura, Ibaraki-ken	x
	JRR-3	1	Tokai-Mura, Ibaraki-ken	x
	JRR-4	1	Tokai-Mura, Ibaraki-ken	x
	Kinki University reactor	1	Higashiosaka-shi, Osaka-fu	x
	KUCA	3	Osaka	x
	KUR	1	Sennan-gun, Osaka	x
	Musashi reactor	1	Kawasaki-shi, Kanagawa-ken	x
	NCA	1	Kawasaki-shi	x
	NSRR	1	Tokai-Mura, Ibaraki-ken	x
	Rikkyo University R.R.	1	Nagasaka, Kanagawa-ken	x
	TCA	1	Tokai-Mura, Ibaraki-ken	x
	TODAI	1	Tokai-Mura, Ibaraki-ken	x
	TTR	1	Kawasaki-shi, Kanagawa-ken	x
	VHTRC	1	Tokai-Mura, Ibaraki-ken	x
Kazakhstan	Kurchatov test reactor	3	Semipalatinsk	—
	WWR-K	1	Almaty	—

Table A20. **FACILITIES UNDER AGENCY SAFEGUARDS (cont.)**

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Korea, Republic of	Triga II and III	2	Seoul	x
	Kyunghee Univ.	1	Suwoon	x
	Hanaro	1	Taejon	x
Latvia	IRT	1	Riga	x
Libyan Arab Jamahiriya	IRT reactor	1	Tajura	x
Malaysia	Puspati	1	Bangi, Selangor	x
Mexico	Triga Mark III	1	Ocoyoacac	x
Netherlands	HOR	1	Delft	x
	HFR	1	Petten	x
	LFR	1	Petten	x
Norway	HBWR-Halden	1	Halden	x
	JEEP-II	1	Kjeller	x
Pakistan	PARR-1	1	Rawalpindi	x
	PARR-2	1	Rawalpindi	x
Peru	RP-0	1	Lima	x
	RP-10	1	Lima	x
Philippines	PRR-1	1	Quezon City, Diliman	x
Poland	Agata and Anna	2	Świerk	x
	Ewa	1	Świerk	x
	Maria	1	Świerk	x
Portugal	RPI	1	Sacavem	x
Romania	Triga II	1	Piteşti Colibaşi	x
	VVR-S	2	Magurele	x
Slovenia	Triga II	1	Ljubljana	x
South Africa	SAFARI-1	1	Pelindaba	x
Sweden	Studsvik RR	2	Studsvik	—
Switzerland	AGN 211P	1	Basel	x
	Crocus	1	Lausanne	x
	Proteus	1	Würenlingen	x
	Saphir	1	Würenlingen	x
Syrian Arab Republic	MNSR	1	Damascus	x
Thailand	TRR-1	1	Bangkok	x
Turkey	Çekmece Nuclear Research and Training Centre	1	Istanbul	x
	ITU-TRR Triga Mark II	1	Istanbul	x
Ukraine	Kiev RR	1	Kiev	—
	IR-100 RR	1	Sevastopol	—
Uruguay	Centro Investigaciones Nucleares	1	Montevideo	x
Uzbekistan	Photon	1	Tashkent	—
	WWR-SM	1	Tashkent	—
Venezuela	RV-I	1	Altos de Pipe	x

Table A20. **FACILITIES UNDER AGENCY SAFEGUARDS (cont.)**

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Viet Nam	Da Lat Research Reactor	1	Da Lat, Lam Dong	x
Yugoslavia Fed. Rep. of	RA-RB	2	Vinèa	x
Conversion plants, including pilot plants				
Argentina	UF_6 production facility		Pilcaniyeu	—
	UO_2 conversion plant		Córdoba	—
Canada	CAMECO		Port Hope	x
Chile	Lab. exper. de conversión		Santiago	x
Japan	JCO conv. plant		Tokai-Mura, Ibaraki-ken	x
	Ningyo R&D		Tomata-gun, Okayama-ken	x
	PCDF		Tokai-Mura, Ibaraki-ken	x
Mexico	Fuel fabrication pilot plant		Salazar	x
Romania	UO_2 powder fabrication plant		Feldioara	—
South Africa	Conversion plant		Pelindaba	x
	HEU-UF_6 production plant		Pelindaba	x
Sweden	Ranstad Mineral		Ranstad	—
Fuel fabrication plants, including pilot plants				
Argentina	Experimental plant		Constituyentes	—
	Fuel fabrication plant		Ezeiza	—
	Fuel fabrication plant		Constituyentes	—
Belgium	BN-MOX		Dessel	x
	FBFC		Dessel	x
	FBFC MOX		Dessel	—
Brazil	Fuel fabrication plant		Resende	x
Canada	CRNL fuel fabrication		Chalk River	x
	Fuel fabrication facility		Chalk River	x
	GEC, Inc.		Toronto	x
	GEC, Inc.		Peterborough	x
	Zircatec		Port Hope	x
Chile	UMF		Santiago	x
Democratic People's Republic of Korea	Nuclear fuel fabrication plant		Nyongbyon	—
Denmark	Metallurgy		Roskilde	x
Egypt	FMPP		Inshas	—
Germany	Adv. Nuclear Fuels		Lingen	x
	NUKEM		Wolfgang	x
	Siemens Uran (two units)		Hanau	x
	Siemens MOX		Hanau	x
India	Ceramic fuel fab. assembly area		Hyderabad	x
	EFFP-NFC		Hyderabad	x
Indonesia	Experimental fuel element installation (IEBE)		Serpong	x
	Research reactor fuel element production installation (IPEBRR)		Serpong	x
Iran, Islamic Rep. of	Fuel fabrication lab.		Esfahan	—

Table A20. **FACILITIES UNDER AGENCY SAFEGUARDS (cont.)**

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Italy	Fabnuc	Bosco Marengo	x
Japan	JNF	Yokosuka-shi, Kanagawa-ken	x
	MNF	Tokai-Mura, Ibaraki-ken	x
	NFI (Kumatori-1)	Sennan-gun, Osaka	x
	NFI (Kumatori-2)	Sennan-gun, Osaka	x
	NFI Tokai	Tokai-Mura, Ibaraki-ken	x
	PFPF	Tokai-Mura, Ibaraki-ken	x
	PPFF	Tokai-Mura, Ibaraki-ken	x
Kazakhstan	Ulbinski Metallurgical Works	Kamenogorsk	—
Korea, Republic of	CANDU fuel fabrication plant	Taejon	x
	KNFFP	Taejon	x
Romania	Romfuel	Pitești Colibasi	x
South Africa	MTR fuel fabrication	Pelindaba	x
	LEU fuel fabrication	Pelindaba	x
Spain	ENUSA fuel fabrication plant	Juzbado	—
Sweden	ABB	Västeras	—
Chemical reprocessing plants, including pilot plants			
Democratic People's Republic of Korea	Radiochemical Laboratory	Bungang-Ri, Nyongbyon	—
Germany	WAK	Eggenstein-Leopoldshafen	x
India	PREFRE	Tarapur	x
Italy	EURE	Saluggia	x
	ITREC-Trisaia	Rotondella	x
Japan	Tokai reprocessing plant	Tokai-Mura, Ibaraki-ken	x
In addition, the following R&D facilities and locations are associated with reprocessing technology:			
Argentina	*Lapep*	*Buenos Aires*	—
	Fission products div.	*Ezeira*	—
Brazil	*Reprocessing project*	*São Paulo*	—
Indonesia	*RMI*	*Serpong*	—
Japan	*SCF*	*Tokai-Mura, Ibaraki-ken*	*x*
	JAERI Tokai R&D	*Tokai-Mura, Ibaraki-ken*	*x*
	PNC Tokai R&D	*Tokai-Mura, Ibaraki-ken*	*x*
	Sumitomi Met. Mining	*Tokai-Mura, Ibaraki-ken*	*x*
Enrichment plants, including pilot plants			
Argentina	Pilcaniyeu enrichment plant	Pilcaniyeu	—
Brazil	Enrichment plant (first cascade)	Resende	—
	Enrichment laboratory	Ipero	—
	Uranium enrichment pilot plant	São Paulo	—
	Laser spectroscopy lab.	San jose dos Campos	—
China	Shaanxi	Han Zhang	—
Germany	UTA-1	Gronau	x
Japan	Uranium Enrichment Plant	Tomata-gun, Okayama-ken	x
	Rokkasho Enrichment Plant	Kamikita-gun, Aomori-ken	x
Netherlands	URENCO	Almelo	x
South Africa	Semi-commercial enrichment plant	Pelindaba	x
	MLIS enrichment plant	Valindaba	—

Table A20. **FACILITIES UNDER AGENCY SAFEGUARDS (cont.)**

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
United Kingdom	URENCO E22	Capenhurst	x
	URENCO A3 plant	Capenhurst	—
In addition, the following R&D facilities and locations are associated with enrichment technology:			
Brazil	*UF_6 laboratory*	*Belo Horizonte*	—
Germany	*Urenco*	*Jülich*	—
Japan	*Asahi Chemical Industry*	*Hyuga-shi, Miyazaki-ken*	*x*
	Hitachi laboratory	*Hitachi-shi, Ibaraki-ken*	*x*
	JAERI Tokai R&D	*Tokai-Mura, Ibaraki-ken*	*x*
	NDC U-Lab.	*Tokai-Mura, Ibaraki-ken*	*x*
	PNC Tokai R&D	*Tokai-Mura, Ibaraki-ken*	*x*
	Toshiba R&D Centre	*Kawasaki-shi, Kanagawa-ken*	*x*
Netherlands	*Urenco*	*Almelo*	*x*
Separate storage facilities			
Argentina	Central store	Ezeiza	x
	Central store	Constituyentes	—
	Nuclear material store	Constituyentes	—
Australia	Vault storage	Lucas Heights	x
Belgium	Belgoprocess	Dessel	x
	Elbel	Beveren	—
	Wet Store	Tihange	—
Brazil	Aramar stores (2 units)	Ipero	—
	UF_6 production facility	São Paulo	—
Bulgaria	Long term storage	Kozloduy	x
Canada	Nuclear material	Chalk River	x
	Spent fuel canister store	Chalk River	x
	Douglas Point dry storage	Tiverton	x
	Gentilly-1	Gentilly	x
	Spent fuel storage	Chalk River	x
	AECL Research	Pinawa	x
	PUFDSF	Pickering	x
Czech Republic	Storage Skoda	Bolevec	x
	HLW store	Reż	—
	ISFS Dukovany	Dukovany	—
Democratic People's Republic of Korea	Nuclear fuel storage	Bungang-Ri, Nyongbyon	—
Denmark	Risø Store	Roskilde	x
	Risø Waste	Roskilde	—
Finland	TVO-KPA store	Olkiluoto	—
France	Cogéma UP2 and UP3	La Hague	x
Germany	Bundeslager	Wolfgang	—
	ANF UF_6 Lager	Lingen	x
	KFA AVR BL	Jülich	—
	KFA AVR	Jülich	x
	BZA-Ahaus	Ahaus	—
	NCS-Lagerhalle	Hanau	—
	Energiewerke Nord GmbH	Lubmin	x

Table A20. **FACILITIES UNDER AGENCY SAFEGUARDS (cont.)**

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Germany (cont.)	Energiewerke Nord-ZLN	Lubmin	—
	Transportbehälterlager	Gorleben	—
	TR Halle 87	Rossendorf	—
	Kernmateriallager	Rossendorf	—
Hungary	Central radionuclide store	Budapest	x
	MVDS	Paks	—
India	AFR	Tarapur	x
Indonesia	TC and ISFSF	Serpong	—
Iraq	Tuwaitha Location C	Tuwaitha	—
Italy	Compes. deposito	Saluggia	x
	Essor nuclear plant	Ispra	—
	Essor storage	Ispra	x
	Research centre	Ispra	—
Japan	KUFFS	Kyoto	x
	Fukushima Dai-Ichi SFS	Futaba-gun, Fukushima-ken	x
	N. S. Mutsu	Mutsu-shi, Aomori-ken	x
	RSFS	Kamikita-gun, Aomori-ken	x
Kazakhstan	Ulbinski Thorium Storage	Kamenogorsk	—
Lithuania	Spent Fuel Dry Storage	Visaginas	—
Netherlands	Covra Store	Vlissingen	—
Pakistan	Hawks Bay depot	Karachi	x
Portugal	Inst. de Armazenagem	Sacavem	x
Russian Federation	Mashinostroitel'nyi Zavod	Ehlektrostal	—
Slovakia	AFRS	Bohunice	x
South Africa	Waste storage	Pelindaba	—
	Bulk storage facility	Pelindaba	x
	HEU storage vault	Pelindaba	x
	Thabana pipe store	Pelindaba	x
Sweden	Central long term storage	Oskarshamn	—
Ukraine	Chernobyl storage	Chernobyl	—
United Kingdom	Special nuclear material store 9	Sellafield	x
	Thorp Plutonium Store	Sellafield	—
United States of America	Pu storage vault	Hanford, WA	—
	Y-12 plant	Oak Ridge, TN	x
	Vault	Golden, CO	—
Other facilities			
Algeria	UDEC	Draria	—
	Es Salam reactor	Ain Oussera	—
Argentina	Alpha facility	Constituyentes	—
	Experimental UO_2 plant	Cordoba	—
	Enriched uranium lab.	Ezeiza	—
	Fission products div.	Ezeiza	—
	Fuel fabrication plant	Ezeiza	—
	LFR	Buenos Aires	—
	Uranium powder fab. plant	Constituyentes	—
	Triple Altura Lab.	Ezeiza	—

Table A20. **FACILITIES UNDER AGENCY SAFEGUARDS (cont.)**

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Australia	Research Lab.	Lucas Heights	x
Belgium	IRMM-Geel	Geel	x
	CEN-Labo	Mol	x
	CEN-Waste	Dessel	—
	I.R.E.	Fleurus	x
	CEN-lab. Pu	Mol	x
Brazil	Fuel tech. co-ord. unit	São Paulo	—
	Isotope laboratory	São Paulo	—
	Metal. uran. project	São Paulo	—
	Nuclear material lab.	Ipero	—
	Nuclear fuel & instr. dev. lab.	São Paulo	—
	Reconversion project	São Paulo	—
	Reprocessing project	São Paulo	—
	Safeguards store	São Paulo	x
Czech Republic	Nuclear Fuel Inst. (UJP)	Zbraslav	x
	Research Laboratories	Řež	x
Democratic People's Republic of Korea	Subcritical assembly	Pyongyang	x
Estonia	Balti ES	Narva	—
Germany	KFA-heisse Zellen	Jülich	x
	KFK-heisse Zellen	Eggenstein-Leopoldshafen	x
	KFK-IHCH	Eggenstein-Leopoldshafen	x
	Siemens heisse Zellen	Karlstein	x
	KFA Lab.	Jülich	x
	Transuran	Eggenstein-Leopoldshafen	x
	VKT. Tec. ZTR	Rossendorf	x
Hungary	Institute of Isotopes	Budapest	x
Indonesia	RMI	Serpong	—
Iran, Islamic Republic of	LWSCR	Esfahan	x
	GSCR	Esfahan	—
Italy	CNEN-LAB. PU.	Santa Maria di Galeria	x
Japan	JAERI-Oarai R&D	Higashi-gun, Ibaraki-ken	x
	JAERI-Tokai R&D	Tokai-Mura, Ibaraki-ken	x
	Kumatori R&D	Sennan-gun, Osaka	x
	Mitsui Iwakuni-Ohtake	Kuga-gun, Yamaguchi	x
	Mitsui Toatsu	Takai-shi, Osaka-fu	x
	NDC Fuel Hot Lab.	Tokai-Mura, Ibaraki-ken	x
	NDC fuel laboratories	Tokai-Mura, Ibaraki-ken	x
	NERL, University of Tokyo	Tokai-Mura, Ibaraki-ken	x
	NFD	Higashi-gun, Ibaraki-ken	x
	NFI Tokai-2	Tokai-Mura, Ibaraki-ken	x
	NRF Neutron Radiation Facility	Tsukuba-shi, Ibaraki-ken	x
	PNC FMF	Higashi-gun, Ibaraki-ken	x
	PNC IRAF	Higashi-gun, Ibaraki-ken	x
	PNC-Oarai R&D	Higashi-gun, Ibaraki-ken	x
	PNC-Tokai R&D	Tokai-Mura, Ibaraki-ken	x
	SCF	Tokai-Mura, Ibaraki-ken	x
	Showa-Kawasaki	Kawasaki-shi, Kanagawa-ken	x
	Sumitomo-Chiba	Sodegaura-shi, Chiba-ken	x
	Uranium Material Laboratory	Higashi-gun, Ibaraki-ken	x

Table A20. **FACILITIES UNDER AGENCY SAFEGUARDS (cont.)**

State[a]	Abbreviated name of facility	Number	Location	Subsidiary arrangements in force
Korea, Republic of	PIEF		Taejon	x
	Acrylonitrile plant		Ulsan	x
	DFDF		Taejon	x
	DUF 4		Taejon	—
	HFFL		Taejon	x
	IMEF		Taejon	x
	KAERI R&D		Taejon	—
Netherlands	ECN and JRC		Petten	x
Norway	Research laboratories		Kjeller	x
Poland	Institute for Nuclear Chemistry and Engineering		Warsaw	—
	Institute of Nuclear Research		Świerk	x
South Africa	Decommissioned pilot enrichment plant		Pelindaba	x
	Decontamination and waste recovery		Pelindaba	x
	Hot Cell Complex		Pelindaba	x
	NU and DU metals plant		Pelindaba	x
Switzerland	EIR		Würenlingen	x
	CERN		Geneva	x
Turkey	Nuclear fuel pilot plant		Istanbul	x
Ukraine	Chernobyl unit 4		Chernobyl	—
	Khmelnitski FF Storage		Neteshin	—
	KHFTI		Kharkov	—
	Rovno FF Storage		Kuznetsovsk	—
	South Ukraine Storage		Yuzhnoukrainsk	—
	Zaporozhe FF Storage		Energodar	—
	Sevastopol subcritical assembly		Sevastopol	—
United States of America	B&W NNFD		Lynchburg, VA	—
	BWXT Facility 179		Lynchburg, VA	—
Non-nuclear installations				
Cuba	Storage of equipment		Prov. Havana	—

[a] An entry in this column does not imply the expression of any opinion whatsoever on the part of the Agency concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

Note: The Agency was also applying safeguards in Taiwan, China, at six power reactors, five research reactors/critical assemblies, one uranium pilot conversion plant, two fuel fabrication plants, two storage facilities and one R&D facility.

Table A21. **MAIN EQUIPMENT AND ACTIVITIES IN SUPPORT OF SAFEGUARDS**

	1998	1999
	Total in inventory	
Gamma ray measurement systems		
Low resolution systems (assay probes)	78	75
High resolution systems (analysers)	42	39
Portable multichannel analysers	304	280
Detectors	759	908
Neutron measurement systems		
Detection heads for active neutron measurements	30	32
Detection heads for passive neutron measurements	34	35
Neutron coincidence counting electronics	102	92
Spent fuel measurement systems		
Cerenkov glow viewing devices	97	96
Spent fuel radiation measuring systems	165	175
Irradiated fuel measuring electronics	77	75
Other measurement systems		
Physical properties devices	147	150
Optical surveillance systems		
Photo cameras	891	715
Video single camera systems	456	505
Video multiple camera systems	65	134
Video review stations	86	142
Seals		
In situ verifiable seals	1 327	1 328
Radiation monitoring systems	74	81
Activities		
Metal cap seals issued	18 600	21 300
Metal cap seals verified	19 301	19 718
Shipment of equipment and supplies	554	534
Hand carried transport of equipment and supplies	656	514
Shipment of reference material and chemicals to facilities	170	289
Shipment of inspection samples, radioactive material standards and contaminated items to the Safeguards Analytical Laboratory	202	232
Procurement actions	1 707	1 423

Table A22. **ADDITIONAL SAFEGUARDS SUPPORT PROVIDED BY STATES**

States and organizations representing groups of States having formal support programmes	States having R&D contracts and test programmes
Argentina	Austria
Australia	Czech Republic
Belgium	Israel
Canada	Latvia
EURATOM	Pakistan
Finland	Russian Federation
France	
Germany	
Hungary	
Japan	
Republic of Korea	
Netherlands	
Russian Federation	
Sweden	
United Kingdom	
United States of America	

Table A23. **STANDING ADVISORY GROUPS**

- Advisory Commission on Safety Standards
- International Consultative Group on Food Irradiation
- International Fusion Research Council
- International Nuclear Data Committee
- International Nuclear Desalination Advisory Group
- International Nuclear Safety Advisory Group
- International Radioactive Waste Technology Advisory Committee
- Nuclear Safety Standards Advisory Committee
- Radiation Safety Standards Advisory Committee
- Scientific Committee of IAEA/WHO Network of Secondary Standard Dosimetry Laboratories
- Standing Advisory Group on Safeguards Implementation
- Standing Advisory Group on Technical Assistance and Co-operation
- Transport Safety Standards Advisory Committee
- Waste Safety Standards Advisory Committee

Table A24. **CONVENTIONS NEGOTIATED AND ADOPTED UNDER THE AUSPICES OF THE AGENCY AND FOR WHICH THE DIRECTOR GENERAL IS THE DEPOSITARY (STATUS AND RELEVANT DEVELOPMENTS)**

Agreement on the Privileges and Immunities of the IAEA (reproduced in INFCIRC/9/Rev. 1). Status remained unchanged during 1999, with 67 Parties.

Vienna Convention on Civil Liability for Nuclear Damage (reproduced in INFCIRC/500). Entered into force on 12 November 1977. In 1999, 1 State adhered to the Convention. By the end of the year, there were 32 Parties.

Optional Protocol Concerning the Compulsory Settlement of Disputes (reproduced in INFCIRC/500/Add.3). Entered into force on 13 May 1999. By the end of the year, there were 2 Parties.

Convention on the Physical Protection of Nuclear Material (reproduced in INFCIRC/274/Rev.1). Entered into force on 8 February 1987. In 1999, 1 State adhered to the Convention. By the end of the year, there were 64 Parties.

Convention on Early Notification of a Nuclear Accident (reproduced in INFCIRC/335). Entered into force on 27 October 1986. In 1999, 2 States adhered to the Convention. By the end of the year, there were 84 Parties.

Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (reproduced in INFCIRC/336). Entered into force on 26 February 1987. In 1999, 2 States adhered to the Convention. By the end of the year, there were 79 Parties.

Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention (reproduced in INFCIRC/402). Entered into force on 27 April 1992. Its status remained unchanged during 1999, with 20 Parties.

Convention on Nuclear Safety (reproduced in INFCIRC/449). Entered into force on 24 October 1996. In 1999, 3 States adhered to the Convention. By the end of the year, there were 52 Parties.

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (reproduced in INFCIRC/546). Opened for signature on 29 September 1997. In 1999, 8 States adhered to the Convention. By the end of the year, there were 13 Contracting States and 40 Signatories.

Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage (reproduced in INFCIRC/566). Opened for signature on 29 September 1997. In 1999, 1 State adhered to the Protocol. By the end of the year, there were 2 Contracting States and 14 Signatories.

Convention on Supplementary Compensation for Nuclear Damage (reproduced in INFCIRC/567). Opened for signature on 29 September 1997. In 1999, 2 States adhered to the Convention. By the end of the year, there were 2 Contracting States and 13 Signatories.

Extension of the African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA) (reproduced in INFCIRC/377). Entered into force on 4 April 1995. In 1999, 2 States adhered to the Extension of the Agreement. By the end of the year, there were 26 Parties.

Second Agreement to Extend the 1987 Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (RCA) (reproduced in INFCIRC/167/Add. 18). Entered into force on 12 June 1997. Status remained unchanged during 1999, with 17 Parties.

Revised Supplementary Agreement Concerning the Provision of Technical Assistance by the IAEA (RSA). In 1999, 1 State concluded the Agreement. By the end of the year, there were 89 States that concluded RSA Agreement.

Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL) (reproduced in INFCIRC/582) Opened for signature on 25 September 1998. In 1999, two States signed the Agreement. By the end of the year, there were 14 Signatories.

Table A25. **CO-ORDINATED RESEARCH PROJECTS**
(with start and finish)

Nuclear Fuel Cycle and Waste Technology	
Evaluation of the safety, environmental and non-proliferation aspects of the partitioning and transmutation of actinides and fission products	1994–2000
Site characterization techniques used in environmental restoration activities	1995–1999
Corrosion of research reactor aluminium clad spent fuel in water	1995–2000
High temperature on-line monitoring of water chemistry and corrosion (WACOL)	1995–2000
Extrapolation of short term observations to time periods for the isolation of long lived radioactive waste	1995–1999
Modelling of transport of radioactive substances in primary circuits of water cooled reactors	1996–2001
Treatment of liquid effluent from mines and mills during and after operation (post-decommissioning/rehabilitation)	1996–2001
Decommissioning techniques for research reactors	1997–2001
Combined methods of liquid radioactive waste treatment	1997–2001
Long term behaviour of low and intermediate level waste packages under repository conditions	1997–2002
Spent fuel performance and research	1997–2002
Chemical durability and performance assessment of spent fuel and high level waste forms under simulated repository conditions	1998–2002
Hydrogen and hydride induced degradation of the mechanical and physical properties of zirconium based alloys	1998–2003
Ageing of materials in spent fuel storage facilities	1999–2003
Anthropogenic analogues for geological disposal of high level and long lived radioactive waste	1999–2003
Comparative Assessment of Energy Sources	
Role of nuclear power and other energy options in meeting international goals on greenhouse gas emission reductions	1999–2001
Estimating external costs associated with electricity generation in developing countries using a simplified approach	1999–2001
Case studies to assess and compare different energy sources in sustainable energy and electricity supply strategies	1997–2000
Impact of infrastructural requirements on the competitiveness of nuclear power	1999–2002
Food and Agriculture	
Use of nuclear techniques for developing integrated nutrient and water management practices for agroforestry systems	1998–2005
Use of isotope techniques in studies on the management of organic matter and nutrient turnover for increased, sustainable agricultural production and environmental preservation	1995–2000
Use of nuclear and related techniques for evaluating the agronomic effectiveness of phosphate fertilizers, in particular rock phosphates	1993–1999
Assessment of soil erosion through the use of caesium-137 and related techniques as a basis for soil conservation, sustainable production and environmental protection	1995–2001
Use of nuclear and related techniques in the management of nutrients and water in rainfed arid and semi-arid areas for increasing crop production	1997–2002
Use of irradiated sewage sludge to increase soil fertility and crop yields and to preserve the environment	1995–1999
Development of management practices for sustainable crop production systems on tropical acid soils through the use of nuclear and related techniques	1999–2004
Radioactively labelled DNA probes for crop improvement	1994–1999
Improvement of new and traditional industrial crops by induced mutations and related biotechnology	1994–1999
Cellular biology and biotechnology including mutation techniques for creation of new useful banana genotypes	1994–1999

Table A25. **CO-ORDINATED RESEARCH PROJECTS (cont.)**

Genetic improvement of under-utilized and neglected crops in low income food deficit countries through irradiation and related techniques	1998–2003
Molecular characterization of mutated genes controlling important traits for seed crop improvement	1999–2004
Mutational analysis of root characters in annual food plants related to plant performance	1999–2004
Improving the effectiveness of monitoring trypanosomosis and tsetse control programmes in Africa using immunoassay and parasitological techniques	1993–1999
Use of radioimmunoassay and related techniques to identify ways of improving artificial insemination programmes for cattle reared under tropical and subtropical conditions	1994–1999
Use of immunoassay technologies for the diagnosis and control of foot and mouth disease in South East Asia	1994–1999
Use of nuclear and colorimetric techniques for measuring microbial protein supply from local feed resources in ruminant animals	1996–2001
Rinderpest seromonitoring and surveillance in Africa using immunoassay technologies	1997–1999
Development and validation of standardized methods for using polymerase chain reaction and related molecular technologies for rapid and improved animal disease diagnosis	1997–2001
Monitoring of contagious bovine pleuropneumonia in Africa using enzyme immunoassays	1997–2002
Use of nuclear and related techniques to develop simple tannin assays for predicting and improving the safety and efficiency of feeding ruminants on tanniniferous tree foliage	1998–2003
Assessment of the effectiveness of vaccination strategies against Newcastle Disease and Gumboro Disease using immunoassay based technologies for increasing farmyard poultry production in Africa	1998–2002
Use of non-structural protein of foot and mouth disease virus to differentiate between vaccinated and infected animals	1999–2004
Medfly mating behaviour studies under field cage conditions	1993–1999
Improved attractants for enhancing the efficiency of tsetse fly suppression operations and barriers systems used in tsetse control/eradication campaigns	1994–2002
Enhancement of the sterile insect technique through genetic transformation of arthropods using nuclear techniques	1994–2002
A molecular and genetic approach to develop sexing strains for field application in fruit fly sterile insect technique programmes	1994–2001
Automation in tsetse mass rearing for use in sterile insect technique programmes	1994–2001
Genetics application to improve the SIT for tsetse control/eradication	1997–2002
Quality assurance of mass produced and released fruit flies	1999–2004
Evaluating the use of nuclear techniques for the colonization and production of natural enemies of agricultural insect pests	1999–2004
Impact of long term pesticide usage on soil properties using radiotracer techniques	1994–1999
Validation of thin layer chromatographic screening methods for pesticide residue analysis	1996–2002
Alternative methods to gas and high performance liquid chromatography for pesticide residue analysis in grain	1997–2002
Development of safe, shelf-stable and ready to eat food through radiation processing	1996–2000
Determination of profiles of bacterial pathogens in food for export by the introduction of quality assured microbial assays	1998–2002
Irradiation as a phytosanitary treatment of food and agricultural commodities	1998–2002
Evaluation of methods of analysis for determining mycotoxin contamination of food and feed	1999–2003
Classification of soil systems on the basis of transfer factors of radionuclides from soil to reference plants	1999–2003
Human Health	
Local production and evaluation of primary reagents for the radioimmunoassay of alpha feto protein	1997–2000

Table A25. **CO-ORDINATED RESEARCH PROJECTS (cont.)**

Molecular typing in the management of multi-drug resistant tuberculosis	1997–2000
Genotype/phenotype correlation in thalassemia and muscular dystrophy	1998–2000
Bone SPECT in the management of patients with unexplained back pain	1997–2000
Relationship between vesico-ureteral reflux, pyelonephritis and renal scarring in children with recurrent urinary tract infection	1997–1999
Evaluation of technetium-99m based radiopharmaceuticals in the diagnosis and management of breast cancer patients	1997–2000
In vivo imaging for infection and inflammation	1996–1999
Diagnosis of subtypes of hepatitis B and C by in vitro nuclear techniques	1999–2002
Diagnosis of Chagas disease using a combination of antigens and radiolabelled probes	1999–2001
Standardization of iodine-131 treatment for hyperthyroidism with an intent to optimize radiation dose and treatment response	1994–1999
Efficacy and toxicity of samarium-153 EDTMP in the treatment of painful skeletal metastases	1996–1999
Relationship between recurrent lower respiratory tract infection, gastroesophageal reflux and bronchial asthma in children	1999–2003
Comparison of clinical applications software in nuclear medicine laboratories by software phantoms developed by COST-B	1999–2003
Development and validation of an Internet based clinical and technical study communication system for nuclear medicine	1998–2001
Clinical application of radiosensitizers in cancer radiotherapy	1994–2001
Randomized clinical trial of radiotherapy combined with mitomycin C in the treatment of advanced head and neck tumours	1994–2003
Use of radiotherapy in advanced cancer	1995–2000
Regional hyperthermia combined with radiotherapy for locally advanced cancers	1997–2002
Aspects of radiobiology applicable in clinical radiotherapy: Increase of the number of fractions per week	1998–2005
Human immunodeficiency virus markers in patients treated with radiotherapy for cervical cancer	1999–2000
Characterization and evaluation of high dose dosimetry techniques for quality assurance in radiation processing	1995–1999
Development of a quality assurance programme for radiation therapy dosimetry in developing countries	1995–2000
Development of a quality assurance programme for Secondary Standard Dosimetry Laboratories	1996–1999
Dose determination with plane parallel ionization chambers in therapeutic electron and photon beams	1996–1999
Development of a Code of Practice for dose determination in photon, electron and proton beams based on measurement standards of absorbed dose to water	1997–2000
Electron paramagnetic resonance biodosimetry	1998–2000
Comparative international studies of osteoporosis using isotope techniques	1994–2000
Development and application of isotopic techniques in studies of vitamin A nutrition	1995–1999
Reference Asian Man Project (Phase 2): Ingestion and organ content of trace elements of importance in radiological protection (RCA)	1995–2000
Isotopic evaluations of maternal and child nutrition to help prevent stunting	1996–1999
Isotopic evaluations in infant growth monitoring — in collaboration with WHO (partly RCA)	1999–2002
Application of nuclear techniques in the prevention of degenerative diseases (obesity and non-insulin dependent diabetes) in ageing	1998–2002
Use of isotopic techniques to examine the significance of infection and other insults in early childhood to diarrhoea morbidity, mal-assimilation and failure to thrive	1999–2003

Table A25. **CO-ORDINATED RESEARCH PROJECTS (cont.)**

Applied research on air pollution using nuclear related analytical techniques in the Asia and Pacific region (RCA)	1995–1999
Assessment of levels and health effects of airborne particulate matter in the mining, metal refining and metal working industries using nuclear and related analytical techniques	1996–2000
Validation and application of plants as biomonitors of trace element atmospheric pollution, analysed by nuclear and related techniques	1997–2002
Health impacts of mercury cycling in contaminated environments studied by nuclear techniques	1999–2004
Marine Environment, Water Resources and Industry	
Worldwide marine radioactivity studies	1998–2001
Use of radiation processing to prepare biomaterials for applications in medicine	1995–1999
Improvement of physical properties of radiation vulcanized natural rubber latex (RVNRL) (RCA)	1997–2000
Radiation processing of indigenous natural polymers (RCA)	1997–2002
Sedimentation assessment studies by environmental radionuclides and their application to soil conservation measures	1995–2000
The use of tracers and stable isotopes in surface water pollution studies	1997–2000
Isotope based assessment of groundwater renewal and related anthropogenic effects in water scarce areas	1995–1999
The use of isotope techniques in investigating acidic fluids in geothermal exploitation	1997–2000
The application of isotope techniques to the assessment of aquifer systems in major urban areas	1997–2000
Isotope response to dynamic changes in groundwater systems due to long term exploitation	1999–2003
Isotope techniques for the assessment of slow moving deep groundwater and their potential application for the assessment of waste disposal sites	1997–2000
Radionuclide transport dynamics in freshwater resources	1997–2001
Radiotracer technology for engineering unit operation studies and unit process optimization	1997–2000
The use of radiation processing for sterilization or decontamination of pharmaceuticals and pharmaceutical raw materials	1998–2001
Validation of protocols for corrosion and deposit evaluation in pipes by radiography	1997–2000
Physical and Chemical Sciences	
Development of computer based troubleshooting tools and instruments	1996–2000
Specialized software utilities for gamma ray spectrometry	1997–2000
Application of nuclear techniques to anti-personnel land mine identification	1999–2002
Bulk hydrogen analysis using neutrons	1997–2000
WIMS Library update	1998–2002
Analysis of research reactor transients	1995–2000
Application of MeV ion beams for development and characterization of semiconductor materials	1997–2000
Development of agents for imaging central neural system receptors based on technetium-99m	1995–2000
Technetium-99m labelled peptide for imaging of peripheral receptors	1995–2000
Optimization of synthesis and quality control procedures for the preparation of fluorine-18 and iodine-123 labelled peptides	1997–2000
Development of kits for radioimmunometric assay of tumour markers	1997–2000
Validation of nuclear techniques for analysis of precious and rare metals in mineral concentrates	1997–2000
Development of radioactively labelled cancer seeking biomolecules for targeted radiotherapy	1997–2000
Engineering, industrial and environmental applications of plasma physics and fusion technologies	1996–1999

Table A25. **CO-ORDINATED RESEARCH PROJECTS (cont.)**

Power plant design for inertial fusion energy	2000–2004
Dense magnetized plasma	2001–2004
Comparison of compact toroid configurations	1998–2002
Nuclear Safety	
Management of ageing of in-containment instrumentation and control cables	1992–1999
Development of methodologies for optimization of surveillance testing and maintenance of safety related equipment at nuclear power plants	1996–1999
Round robin exercise on WWER-440 reactor pressure vessel weld metal irradiation embrittlement and annealing	1996–2000
Investigation of methodologies for incident analysis	1997–2000
Safety of RBMK type nuclear power plant in relation to external events	1997–2000
Development and application of indicators to monitor nuclear power plant operational safety performance	1999–2003
Radiation Safety	
Development of relevant accident data for quantifying risks associated with transport of radioactive material	1994–1999
Limitations of radioepidemiological assessments for stochastic radiation effects, in relation of radiation protection	1994–2000
Intercomparison of in vivo counting systems using a reference Asian phantom	1996–1999
Regional personal dosimetry intercomparison	1996–1999
Intercomparison for individual monitoring of external exposure from photon radiation	1996–2000
Intercomparison and biokinetic model validation of radionuclide intake assessment	1997–2000
Development of radiological basis for the transport safety requirements for low specific activity materials and surface contaminated objects	1997–2001
Accident severity during air transport of radioactive material	1998–2001
Cytogenetic biodosimetry	1998–2002
Image quality and patient dose optimization in mammography in eastern European countries	1999–2003
Radioactive Waste Safety	
Formulation of approaches to compare the potential impacts of wastes from electricity generation technologies	1997–2000
Improvement of safety assessment methodologies for near surface disposal facilities for radioactive waste (ISAM)	1997–2000
Biosphere modelling and assessment methods (BIOMASS)	1998–2002

Table A26. **TRAINING COURSES, SEMINARS AND WORKSHOPS IN 1999**

Nuclear Power

National workshop on nuclear power project planning — Bangladesh

Regional workshops on Y2K issues: Interface between electricity grid performance and nuclear power plant operation — Bulgaria

Regional workshop on experience in delayed nuclear power projects — Brazil

Regional workshop on human resources management — Slovenia

Regional workshop on commissioning and project management — China

Regional workshop on steam generator degradation and inspection — France

Regional workshop on quality performance in niclear power plants: The role of management — Hungary

Interregional training course on instrumentation and control of nuclear power plants — Germany

Workshop on cost and process management for Latin America — Argentina

Regional workshop on human resources management with special focus on training and licensing — Rep. of Korea

Regional workshop on qualification of non-destructive testing systems — Croatia

Regional workshop on qualification of in-service inspection systems — Cuba

Regional workshop on optimization of in-service inspection programmes of primary circuit components — Slovakia

Nuclear Fuel Cycle and Waste Technology

Workshop on regulatory aspects of decommissioning — Italy

Seminar on nuclear graphite disposal — United Kingdom

Regional course on WWER fuel design, fabrication, performance and the back end — Slovakia

Workshop for the users of the TRANSURANUS code — Bulgaria

Interregional course on technical and administrative preparations required for the shipment of research reactor spent fuel to its country of origin — USA

Comparative Assessment of Energy Sources

Interregional course on energy and nuclear power planning using the Energy and Power Evaluation Program (ENPEP) — USA

Regional (Europe) course on the comparative assessment of nuclear power and other options and strategies for electricity generation in support of sustainable energy development — Italy

Regional (RCA) course on use of the Agency's DECADES computer tools and FINPLAN model to analyse the role of nuclear power in light of increased privatization in the electricity sector — Pakistan

Regional (RCA) seminar to exchange information and experience on national efforts in developing country specific databases to support comparative assessment — Thailand

National course on use of the Agency's MAED model for electricity demand forecasting — Sudan

Workshop on estimating external costs associated with electricity generation in developing countries, using a simplified approach — Italy

Workshop on exchange of experience in enhanced electricity planning incorporating comparative assessment into decision support studies — Brazil

Food and Agriculture

Regional group training on fertigation and the use of nuclear techniques in water and nutrient management — Jordan

FAO/IAEA regional seminar on extension aspects of agroforestry practices — Sri Lanka

Regional workshop on evaluation of the dynamics of nutrients and water in cropping systems — Chile

FAO/IAEA seminar on mutation techniques and molecular genetics for tropical and subtropical plant improvement in the Asia and Pacific region — Philippines

FAO/IAEA regional workshop on hands-on experience in molecular and mutation techniques — Austria

Table A26. **TRAINING COURSES, SEMINARS AND WORKSHOPS IN 1999 (cont.)**

Review and planning workshop for the Asia and Pacific region on feed supplementation strategies and reproductive management of cattle — Myanmar

First project co-ordination meeting of the IAEA/AFRA project on increasing and improving milk and meat production — Morocco

Project co-ordination meeting and mid-term review of AFRA project II–17 development and field evaluation of animal feed supplementation packages — Madagascar

Regional workshop on African swine fever — Senegal

IAEA/RCA regional training workshop on self-coating solid phase radioimmunoassay for measuring progesterone in milk of ruminant livestock — Indonesia

IAEA/AFRA training workshop on the production of iodinated tracers for self-coating radioimmunoassay of progesterone — Egypt

Fifth co-ordination meeting on support for rinderpest surveillance — Syrian Arab Republic

Regional FAO/IAEA workshop on internal quality control of the rinderpest enzyme linked immunosorbent assay (ELISA) and ELISA troubleshooting — Senegal

FAO/IAEA regional course on the diagnosis and control of foot and mouth disease — Thailand

Task force meeting on training of artificial insemination technicians, field assessment of fertility and database management — South Africa

Second workshop on quarantine procedures needed for the creation of a fruit fly free zone in Tacna and Moquegua — Peru

FAO/IAEA interregional course on the use of the sterile insect and related techniques for the area-wide management of insect pests — USA

FAO/IAEA regional course on techniques used for area-wide control/eradication of the Old World Screwworm fly — Malaysia

Third meeting of the working group on fruit flies of the Western Hemisphere — Guatemala

Second national course on integrated fruit fly control — Peru

FAO/IAEA course for Asia and the Pacific on the development of quality assurance for mycotoxin analysis of food and feed — Philippines

FAO/IAEA workshop on the introduction of quality assurance/quality control measures in pesticide residue analytical laboratories — Austria

Human Health

Regional course for diagnosis of diabetic nephropathy using radioimmunoassay techniques — India

Regional course on cardiac SPECT for nuclear medicine technologists — Thailand

Regional course on myocardial perfusion scintigraphy for nuclear medicine physicians — Philippines

Regional course on nuclear cardiology — India

Regional course on radionuclide techniques in the management of diabetic nephropathy — Republic of Korea

Regional course on myocardial perfusion studies using SPECT — China

Regional workshop on recent serological and tissue markers for breast cancer — China

Regional course on application of radionuclide techniques in oncology — Slovenia

Regional course on nuclear cardiology — Islamic Republic of Iran; Hungary

Regional course on quality control and SPECT systems — Egypt

Regional workshop on effective use of portable image processing software — Kenya; Morocco

Regional course on use and production of genotyping diagnostic reagents — Republic of Korea

Regional workshop on screening for neonatal hypothyroidism — Thailand

Regional workshop on national screening programme for neonatal hypothyroidism — Republic of Korea

Regional workshop on methodological aspects of tumour markers to ferritin and CEA — Ghana

Table A26. **TRAINING COURSES, SEMINARS AND WORKSHOPS IN 1999 (cont.)**

Regional workshop on the radioimmunoassay of tumour markers for diagnosis and management of cancer — Islamic Republic of Iran

Regional workshop on training and evaluation of methodologies for screening and confirmation of hepatitis C using radioimmunoassay— Costa Rica

Regional course on isotopes and molecular techniques for diagnosis and control of communicable diseases — South Africa

Regional workshop on quality control of single and multi-head SPECT systems — Saudi Arabia

Regional course on maintenance of gamma cameras — Syrian Arab Republic

Regional course on quality control of medical linear accelerators — Islamic Republic of Iran

Regional course on quality assurance of SPECT systems — Costa Rica

International seminar on therapeutic application of radiopharmaceuticals — India

National workshop on intraluminal and interstitial brachytherapy — Islamic Republic of Iran

Evidence based radiation oncology — South Africa

Regional workshop on health planners and harmonization of education — South Africa

Course on modern brachytherapy techniques — Norway

Teaching course on methodology of clinical research — Italy

Course on imaging for target volume determination in radiotherapy — United Kingdom

Project co-ordinators' meeting on quality assurance in radiation therapy — Australia

Regional course on public and professional awareness — Sri Lanka

Interregional course on clinical treatment planning for teletherapy and brachytherapy — Lithuania

Regional course on the basis for clinical quality assurance radiation oncology — Philippines

Regional course on breast conservation techniques for breast cancer — Morocco

Teaching course on evidence based radiation oncology: Principles and methods (in Russian) — Slovakia

Regional course on the basis for clinical quality assurance in radiation oncology — Philippines

Regional course on modern techniques and dosimetry in brachytherapy — Egypt

Regional workshop on the IAEA and ESTRO networks for external quality audits in radiotherapy — Greece

Interregional course on treatment planning in radiotherapy using ROCS^{TM} systems — Lithuania

Interregional course on calibration procedures and quality assurance in Secondary Standard Dosimetry Laboratories — Cuba

Regional workshop on harmonized methods of beam calibrations in external radiotherapy (AFRA) — Morocco

Regional course on application of chemometrics and statistics for the evaluation of airborne particulate matter data and black carbon analysis of aerosol samples — Indonesia

Regional course for East Asia and the Pacific on isotopic technique applications in human nutrition with emphasis on micronutrient intervention programmes — Thailand

Course on quality assurance — Austria

Regional workshop on sampling and sample preparation — Brazil

National course on the use of isotopes in human nutrition — Egypt

Workshop on efficient methodology for the evaluation of uncertainty in analytical chemistry — Finland

Determination of radionuclides in food and environmental samples — Japan

Workshop on standards, intercomparison and performance evaluations for low level and environmental mass spectrometry — USA

Workshop on mobile radiological laboratories — Ukraine

Table A26. **TRAINING COURSES, SEMINARS AND WORKSHOPS IN 1999 (cont.)**

Marine Environment, Water Resources and Industry

Assessment workshop on the development of hydrological conceptual models — Viet Nam

Regional workshop on isotope data interpretation and integration in site conceptual models — South Africa

Regional course on techniques for reservoir management — Philippines

Workshop on assessment of technology transfer in geothermal energy development —Indonesia

Regional course on cross-correlation techniques for flow rate measurement in multiphase systems — Malaysia

Regional course on radiotracer and sealed source applications in the petroleum industry — India

Regional workshop on industrial applications of tracer technology and nucleonic control systems — Venezuela

Regional course on level 3 examinations in surface methods (penetrant testing and magnetic particle testing) — Pakistan

Regional course and examination on radiographic testing: Level 2 — Islamic Republic of Iran

Regional course on non-destructive testing of concrete structures —Malaysia

Regional course on non destructive testing in-service inspection for industry —Saudi Arabia

Regional course and examination on ultrasonic testing: Level 2 — Syrian Arab Republic

Regional course on radiation synthesis of biomaterials — Australia

Regional course on radiation upgrading of agro wastes — Malaysia

Regional course on production and sterilization of biological tissues — Algeria

Regional course on radiation treatment of industrial and municipal wastewater — Austria

Regional course on production and control of radiopharmaceuticals — Saudi Arabia

Regional workshop on quality assurance in the production and control of iodine-131 therapeutic capsules — Viet Nam

Regional workshop on quality assurance in the production and control of therapeutic radiopharmaceuticals — Republic of Korea

Regional workshop on good manufacturing practices in the production of technetium-99m generators — China

Course on antibody coated tubes production and evaluation for use in radioimmunoassay/immunoradiometric assay — Greece

Regional expert workshop on quality assurance in cobalt-60 brachytherapy source production — India

Regional course on the training of auditors of nuclear analytical laboratories — Bolivia

Regional course on calibration and metrology in nuclear analytical techniques — Chile

Working group meetings on preparation of a programme for the harmonization of quality assurance procedures in radiopharmacy — Cuba; Argentina

Regional course on the preparation and quality control of iodine-131–MIBG for diagnoses and therapy — Brazil

Regional workshop on training in quality analysis/quality control of nuclear analytical techniques — Austria

Physical and Chemical Sciences

Regional course on the maintenance, repair and calibration of electrometers and ionization chambers in Latin America — Brazil

Regional course on power supplies — Malaysia

Regional course on troubleshooting of nuclear instruments — Indonesia

Group fellowship training in the maintenance of nuclear spectroscopy instruments — Agency's Laboratories, Seibersdorf

National workshop for environmental officers — Ghana

National course on power conditioning and earthing — Zambia

Table A26. **TRAINING COURSES, SEMINARS AND WORKSHOPS IN 1999 (cont.)**

Regional workshop on the management of research reactor facilities — Egypt

Nuclear Safety

Interregional course on environmental qualification of equipment important to safety in nuclear power plants — Spain

Regional course on regulatory control of nuclear power plants — United Kingdom

Regional course: Basic professional course on nuclear safety — France

Regional course on train the trainers in nuclear safety, including the use of basic simulators for training of nuclear power plant technical personnel — Slovenia

Advanced course on probabilistic safety assessment (PSA) modelling techniques, including human reliability analysis, common cause failure, Level 2 shutdown PSA and an overview of PSA applications — Spain

Joint utility/regulatory benefits of periodic safety reviews — Hungary

Safety assessment of plant modifications with emphasis on instrumentation and control modernization and human–machine interface issues — Slovenia

Development and validation of emergency operating procedures for effective prevention/mitigation of severe core damage — Slovakia

Nuclear power plant operating cycle extension (on-line maintenance, maintenance optimization, in-service inspection, technical specification applicability) — Slovenia

Safety issues for RBMK reactors — Lithuania

Application of selected event analysis methodologies to actual events from nuclear power plants — Slovakia

Utility–regulatory interface for nuclear power plant safety — Germany

Management of safety and safety culture — Bulgaria

Enhancement of operational safety — Slovenia

Regulatory experience in introducing advanced computer based technology into safety systems at nuclear power plants — Slovenia

Forum on safety analysis for WWER and RBMK reactors — Russian Federation

Workshop on regulatory review of licensee safety performance — Spain

Course on simulator training — Republic of Korea

Course on mechanical equipment — Republic of Korea

Course on steam generators — Republic of Korea

Workshop on the licensing of modifications — Slovenia

Workshop on co-operation issues between the regulatory body and other authorities involved in the licensing process — Czech Republic

Course on human resources management with special focus on training and licensing — Republic of Korea

Course on commissioning and project management — China

Course on application of the technical co-operation regional Asia reference book in cascade training with special focus on maintenance — Republic of Korea

Course on plant specific safety indicators for monitoring operational safety performance — China; India; Pakistan

Course on self-assessments and peer reviews — China

Course on methods to detect, correct and prevent human errors — India

Course on education and training for safety — Republic of Korea

Course on ageing and plant life extension — Republic of Korea

Radiation Safety

Basic regional professional course on radiation protection — Syrian Arab Republic

Regional workshop on notification, authorization, inspection and enforcement — France

Table A26. **TRAINING COURSES, SEMINARS AND WORKSHOPS IN 1999 (cont.)**

Regional workshop on the development of national external individual monitoring services with emphasis on thermoluminescence dosimetry, operation and management — Côte d'Ivoire

Regional workshop on radiation protection and quality assurance in diagnostic radiology — Ghana

Regional post-graduate educational course on radiation protection — South Africa

Research reactor emergency response exercise — Australia

Regional (RCA) workshop on radiation protection and quality assurance, including optimization of collective dose from diagnostic radiology — Malaysia

Regional (RCA) workshop on occupational radiation protection — Australia

Regional (RCA) course on radiation safety in industrial radiography — Indonesia

Regional (RCA) workshop on current ICRP recommendations and IAEA standards — India

Group training on design, implementation and management of radiation protection and safety programme in industrial radiography — Malaysia

National workshop on radiation protection in radiodiagnostic, radiotherapy and nuclear medicine — Myanmar

National workshop on radiation protection and quality assurance in radiodiagnostics — Austria

Group training on operation and maintenance of the Harshaw thermoluminescent dosimeter reader — Germany

Group training on radiation protection and quality assurance in diagnostic radiology — United Kingdom

Group training on radiation protection and quality assurance in radiotherapy — Belgium

Group course on the safe transport of radioactive waste material — Syrian Arab Republic

Basic regional professional course on radiation protection — Syrian Arab Republic

Regional course on optimization of radiological protection in the design and operation of nuclear power plants — Russian Federation

Regional train the trainers course on medical preparedness and assistance for radiological accidents — Czech Republic

Regional course on medical preparedness and emergency medical assistance to nuclear and radiological accidents: Echo 1 — Hungary

Regional course on biodosimetry and diagnosis of health effects of exposure to ionizing radiation — Turkey

Regional train the trainers course on monitoring strategies, procedures, reporting and transmission of data (in English) — Ukraine

Regional train the trainers course on monitoring strategies, procedures, reporting and transmission of data (in Russian) — Ukraine

Regional train the trainers course on radiological emergency preparedness (in English) — Slovenia

Regional train-the-trainers course on radiological emergency preparedness (in Russian) — Russian Federation

Regional course on safety assessment and inspection in medical, industrial and research facilities — Lithuania

Regional course on radiation protection and safety in medicine — Belarus

Regional course on design, implementation and management of individual monitoring programmes — Czech Republic

Regional basic course on radiation protection — Russian Federation

National course on radiation protection for radiation protection officers — The Former Yugoslav Republic of Macedonia

National course on radiation protection in medical practices — Republic of Moldova

National course on radiation and quality assurance in medicine — Latvia

Regional course for regulatory staff on the control of medical practice in radiotherapy — Mexico

Table A26. **TRAINING COURSES, SEMINARS AND WORKSHOPS IN 1999 (cont.)**

Regional workshop on radiation protection and regulatory control in industrial applications of radiation sources — Chile

Second intercomparison of personal monitoring and workshop on external personal dosimetry — Guatemala

National course on emergency response and preparedness for national organizations — Panama

National course on medical aspects of radiological accidents — Argentina

Regional course on radiological protection in X ray diagnosis — Brazil

Regional course on radiation protection and nuclear safety — Argentina

Regional course on safe transport of radioactive materials — Argentina

Radioactive Waste Safety

Regional (RCA) workshop on environmental radiation monitoring and regional database — Republic of Korea

Regional basic course on radioactive waste safety — Republic of Moldova

Regional train the trainers workshop on decontamination of contaminated villages — Belarus

Regional course on physical protection of nuclear facilities and materials — Czech Republic

Safeguards

International course on state systems of accounting and control of nuclear materials — USA

Seminar on IAEA safeguards for the 21st century — Republic of Korea

Workshop on familiarization of IAEA activities and non-destructive analysis measurement techniques — Belarus; Uzbekistan

Workshop on containment and surveillance equipment and procedures for ABACC inspectors — Brazil; Argentina

Security of Material

LANL/IAEA joint international workshop on radiation monitoring — USA

Interagency co-ordination committee working group on training — Austria

Workshop on IAEA safeguards implementation — Austria

Joint IAEA–WCO–INTERPOL awareness training course for customs and police investigators on combating smuggling of nuclear and other radioactive materials — Austria

Nuclear Non-Proliferation Experts Group evaluation of exercise — Austria; Malta

Regional workshop on the illicit trafficking database — Kazakhstan

Workshop on design basis threat — Czech Republic

Workshop on nuclear materials accountancy and control — Austria

Regional workshop on physical protection of nuclear facilities and materials — Cyprus

International course on physical protection — USA

Table A27. **PUBLICATIONS ISSUED IN 1999**

Nuclear Power

Nuclear power reactors in the world — Reference Data Series No. 2

Operating experience with nuclear power stations in Member States in 1998 (13th edition) — Annual Publication

Verification and validation of software related to nuclear power plant instrumentation and control — Technical Reports Series No. 384

Modern instrumentation and control for nuclear power plants: A Guidebook — Technical Reports Series No. 387

World survey on nuclear power plant personnel training — IAEA-TECDOC-1063

Specification of requirements for upgrades using digital instrument and control systems — IAEA-TECDOC-1066

Technical support for nuclear power operations — IAEA-TECDOC-1078

Quality assurance within regulatory bodies — IAEA-TECDOC-1090

The impact of the year 2000 issue on electricity grid performance and nuclear power plant operation in Bulgaria, the Russian Federation and Slovakia — IAEA-TECDOC-1095

Evaluating and improving nuclear power plant performance — IAEA-TECDOC-1098

Management of delayed nuclear power projects — IAEA-TECDOC-1110

Strategies for competitive nuclear power plants — IAEA-TECDOC-1123

Nuclear Fuel Cycle and Waste Technology

Hydrogeological investigation of sites for the geological disposal of radioactive waste — Technical Reports Series No. 391

State of the art technology for decontamination and dismantling of nuclear facilities — Technical Reports Series No. 395

Hydrogeological investigations of sites for geological disposal of radioactive waste — IAEA-TECDOC-931

Remote technology in spent fuel management — IAEA-TECDOC-1061

Procedures and techniques for the management of experimental fuels from research and test reactors — IAEA-TECDOC-1080

Spent fuel storage and transport cask decontamination and modification — IAEA-TECDOC-1081

Potential vulnerabilities of nuclear fuel cycle facilities to the year 2000 (Y2K) issue and measures to address them — IAEA-TECDOC-1087

Technologies for the remediation of radioactively contaminated sites — IAEA-TECDOC-1086

Technical options for the remediation of contaminated groundwaters — IAEA-TECDOC-1088

Storage of spent fuel from power reactors: Proceedings of a symposium — IAEA-TECDOC-1089

Maintenance of records for radioactive waste disposal — IAEA-TECDOC-1097

Review of the factors affecting the selection and implementation of waste management technologies — IAEA-TECDOC-1096

Survey of wet and dry spent fuel storage — IAEA-TECDOC-1100

Status and trends in spent fuel reprocessing — IAEA-TECDOC-1103

Minimization of waste from uranium purification, enrichment and fuel fabrication — IAEA-TECDOC-1115

Use of natural analogues to support radionuclide transport models for deep geological repositories for long lived radioactive wastes — IAEA-TECDOC-1109

Compliance monitoring for remediated sites — IAEA-TECDOC-1118

On-site disposal as a decommissioning strategy — IAEA-TECDOC-1124

Water chemistry and corrosion control of cladding and primary circuit components — IAEA-TECDOC-1128

Nuclear decommissioning: A proposed standardized list of items for costing purposes

Table A27. **PUBLICATIONS ISSUED IN 1999 (cont.)**

Comparative Assessment of Energy Sources

Strategies for competitive nuclear power plants — IAEA-TECDOC-1123

Energy, electricity and nuclear power estimates for the period up to 2020, July 1999 Edition — Reference Data Series No. 1

Food and Agriculture

Soils newsletter, Vol. 22, Nos 1 and 2

Mutation breeding newsletter No. 44

Mutation breeding review No. 11

Animal production and health newsletter Nos 30 and 31.

Insect and pest control newsletter Nos 53 and 54

Plant breeding and genetics newsletter Nos 3 and 4

Nuclear based technologies for estimating microbial protein supply in ruminant livestock — IAEA-TECDOC-1093

Development of feed supplementation strategies for improving the productivity of dairy cattle on smallholder farms in Africa — IAEA-TECDOC-1102

The South American fruit fly *Anastrepha fraterculus* (Wied.): Advances in artificial rearing, taxonomic status and biological studies — IAEA-TECDOC-1064

Development of a female medfly attractant system for trapping and sterility assessment — IAEA-TECDOC-1099

Product quality control, irradiation and shipping procedures for mass-reared tephritid fruit flies for sterile insect release programmes

Irradiation as a quarantine treatment of arthropod pests — IAEA-TECDOC-1082

Use of nuclear and related techniques in studies of agroecological effects resulting from the use of persistent pesticides in Central America — IAEA-TECDOC-1116

Facts about food irradiation (2nd edition), ICGFI

Safeguarding our harvest, ICGFI

Irradiation and trade in food and agricultural commodities, ICGFI

Enhancing food safety through irradiation, ICGFI

Consumer attitudes and marketing response to irradiated food, ICGFI

The safety of poultry meat: from farm to table, ICGFI

Human Health

Handbook for mould room for teletherapy — IAEA-PRTM-4

Techniques for high dose dosimetry in industry, agriculture and medicine. Proceedings of an international symposium — IAEA-TECDOC-1070

Calibration of brachytherapy sources: guidelines on standardized procedures for the calibration of brachytherapy sources at Secondary Standard Dosimetry Laboratories (SSDLs) and hospitals — IAEA-TECDOC-1079

SSDL network charter: IAEA/WHO network of Secondary Standard Dosimetry Laboratories — IAEA/WHO/SSDL/99

SSDL newsletter Nos 40, 41

Marine Environment, Water Resources and Industry

Nuclear geophysics and its applications — Technical Report Series No. 393

Stability and stabilization of polymers under irradiation — IAEA-TECDOC-1062

Production technologies for molybdenum-99 and technetium-99m — IAEA-TECDOC-1065

Characterization of ceramics and semiconductors using nuclear techniques — IAEA-TECDOC-1069

Table A27. **PUBLICATIONS ISSUED IN 1999 (cont.)**

Optimization of production and quality control of therapeutic radionuclides and radiopharmaceuticals — IAEA- TECDOC-1114

NDT: A guidebook for industrial management and quality control personnel — Training Course Series No. 9

Ultrasonic testing of materials at Level 2 — Training Course Series No. 10

Physical and Chemical Sciences

17th IAEA Fusion Energy Conference — Proceedings Series

Nuclear Fusion, Vol.39, Yokohama Special Issues 1 and 2 (selected papers from the 17th IAEA Fusion Energy Conference)

Nuclear Fusion Vol. 39, No. 12, "ITER Physics Basis

Environmental and industrial applications of nuclear analytical techniques — IAEA-TECDOC-1121

Intercomparison of alpha particle spectrometry software packages (with the companion diskette containing the set of test spectra and programs used for analysis) — IAEA-TECDOC-1104

ITER Newsletter

ITER Final Design Report, Cost Review and Safety Analysis (FDR) and Relevant Documents — ITER EDA Documentation Series No. 14

ITER Council Proceedings 1998 — ITER EDA Documentation Series No. 15

Nuclear Safety

Topical issues in nuclear, radiation and radioactive waste safety — Proceedings Series

Implementation and review of a nuclear power plant ageing management programme — Safety Reports Series No. 15

Health and environmental impacts of electricity generation systems: Procedures for comparative assessment — Technical Reports Series No. 394

Light water reactor generic safety issues database (LWRGSIDB). User's manual — IAEA-CMS-13

RBMK fuel channel integrity — IAEA-EBP-RBMK-05

Anticipated transients without scram for WWER reactors — IAEA-EBP-WWER-12

Final report of the programme on the safety of WWER and RBMK nuclear power plants — IAEA-EBP-WWER-15

AMAT guidelines. Reference document for the IAEA Ageing Management Assessment Teams (AMATs) — IAEA-SVS-04

DSRS guidelines. Reference document for the IAEA Design Safety Review Services — IAEA-SVS-05

Achieving year 2000 readiness: Basic processes — IAEA-TECDOC-1072

A framework for a quality assurance programme for PSA — IAEA-TECDOC-1101

Living probabilistic safety assessment (LPSA) — IAEA-TECDOC-1106

Root cause analysis for fire events at nuclear power plants — IAEA-TECDOC-1112

Assessment and management of ageing of major nuclear power plant components important to safety: PWR vessel internals — IAEA-TECDOC-1119

Assessment and management of ageing of major nuclear power plant components important to safety: PWR pressure vessels — IAEA-TECDOC-1120

Self-assessment of operational safety for nuclear power plants — IAEA-TECDOC-1125

A simplified approach to estimating reference source terms for LWR designs — IAEA-TECDOC-1127

Radiation Safety

Safety of radiation sources and security of radioactive materials — Proceedings Series

Radiation protection and safety in industrial radiography — Safety Reports Series No. 13

Assessment of doses to the public from ingested radionuclides — Safety Reports Series No. 14

Occupational radiation protection — Safety Standards Series RS-G-1.1

Table A27. **PUBLICATIONS ISSUED IN 1999 (cont.)**

Assessment of occupational exposure due to intakes of radionuclides — Safety Standards Series RS-G-1.2

Assessment of occupational exposure due to external sources of radiation — Safety Standards Series RS-G-1.3

National competent authorities responsible for approvals and authorizations in respect of the transport of radioactive material - List No. 30 (1999 edition) — IAEA-NCAL-30

Organization and implementation of a national regulatory infrastructure governing protection against ionizing radiation and the safety of radiation sources — IAEA-TECDOC-1067

Intercomparison and biokinetic model validation of radionuclide intake assessment — IAEA-TECDOC-1071

Safety measures to address the year 2000 issue at medical facilities which use radiation generators and radioactive materials — IAEA-TECDOC-1074

Generic procedures for monitoring in a nuclear or radiological emergency — IAEA-TECDOC-1092

Directory of national competent authorities' approval certificates for package design, special form material and shipment of radioactive material. 1999 Edition — IAEA-TECDOC-1107

Report of the international workshop on safety measures to address the year 2000 issue at medical facilities which use radiation generators and radioactive materials — IAEA-TECDOC-1108

Safety assessment plans for authorization and inspection of radiation sources — IAEA-TECDOC-1113

Intercomparison for individual monitoring of external exposure from photon radiation — IAEA-TECDOC-1126

Report on the preliminary fact finding mission following the accident at the nuclear fuel processing facility in Tokaimura, Japan — IAEA-TOAC

Radioactive Waste Safety

Safety assessment for near surface disposal of radioactive waste — Safety Standards Series WS-G-1.1

Decommissioning of nuclear power plants and research reactors — Safety Standards Series WS-G-2.1

Decommissioning of medical, industrial and research facilities — Safety Standards Series WS-G-2.2

Near surface disposal of radioactive waste — Safety Standards Series WS- R-1

Application of radiological exclusion and exemption principles to sea disposal — IAEA-TECDOC-1068

Safety measures to address the year 2000 issue at radioactive waste management facilities — IAEA-TECDOC-1073

Critical groups and biospheres in the context of radioactive waste disposal — IAEA-TECDOC-1077

Protection of the environment from the effects of ionizing radiation — IAEA-TECDOC-1091

Inventory of radioactive waste disposals at sea — IAEA-TECDOC-1105

Report of the international workshop on safety measures to address the year 2000 issue at radioactive waste management and nuclear fuel cycle facilities — IAEA-TECDOC-1111

Co-ordination of Safety Activities

The safe management of sources of radiation: Principles and strategies — INSAG Series No. 11

Basic safety principles for nuclear power plants 75-INSAG-3 Rev. 1 — INSAG Series No. 12

Management of operational safety in nuclear power plants — INSAG Series No. 13

Safe management of the operating lifetimes of nuclear power plants — INSAG Series No. 14

Nuclear safety review for the year 1998 — IAEA/NSR/1998

Regulation of the life cycle of nuclear installations — IAEA-PDRP-3

Assessment of regulatory effectiveness — IAEA-PDRP-4

Communications on nuclear, radiation, transport and waste safety: A practical handbook — IAEA-TECDOC-1076