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CONTENTS

LIST OF ABBREVIATIONS

ARCAL	Regional Co-operative Arrangements for the Promotion of Nuclear Science and Technology in Latin America
CANDU	Canadian deuterium-uranium (reactor)
CEC	Commission of the European Communities
CERN	European Organization for Nuclear Research
CMEA	Council for Mutual Economic Assistance
CRP	Co-ordinated research programme
EEC	European Economic Community
ELISA	Enzyme linked immunosorbent assay
EURATOM	European Atomic Energy Community
FAO	Food and Agriculture Organization of the United Nations
HTGR	High temperature gas cooled reactor
ICRP	International Commission on Radiological Protection
ICRU	International Commission on Radiation Units and Measurements
ICTP	International Centre for Theoretical Physics
IEA	International Energy Agency (OECD)
IGCP	International Geological Correlation Programme
IIASA	International Institute for Applied Systems Analysis
ILMR	International Laboratory of Marine Radioactivity
ILO	International Labour Office
IMO	International Maritime Organization
INDC	International Nuclear Data Committee
INTOR	International Tokamak Reactor
ISO	International Organization for Standardization
LMFBR	Liquid metal cooled fast breeder reactor
LWR	Light water reactor
NDA	Non-destructive assay
NEA	Nuclear Energy Agency of the OECD
NENS	Division of Nuclear Safety (IAEA)
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
NUSS (programme)	The Agency's programme on nuclear safety standards for nuclear power plants
NWAL	Network of Analytical Laboratories
OAU	Organisation for African Unity
OECD	Organisation for Economic Co-operation and Development
OPANAL	Organismo Proscripción Armas Nucleares América Latina Caribe
PHWR	Pressurized heavy water reactor
PWR	Pressurized water reactor
R&D	Research and development
RCA	Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (INFCIRC/167)
RIFA	Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
RIPC	Division of Physical and Chemical Sciences (IAEA)
SAL	Safeguards Analytical Laboratory
SQ	Significant quantity
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
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
VIC	Vienna International Centre
WANO	World Association of Nuclear Operators
WASP	Wien Automatic System Planning Package
WHO	World Health Organization
WMO	World Meteorological Organization
WOCA	World outside centrally planned economies area
WWER	Water cooled and moderated reactor (Soviet Union)

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1. All sums of money are expressed in United States dollars.

2. 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.

3. 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.

Introduction

The Agency in 1989

The Regular Budget for 1989, at an exchange rate of 13.18 Austrian schillings to one United States dollar, amounted to $152 520 000, of which $143 749 000 was to be financed from contributions by Member States on the basis of the 1989 scale of assessment, $5 045 000 from income from work for others and $3 726 000 from other miscellaneous income.

At the end of 1989, the number of members of the Secretariat was 2171 — 825 in the Professional and higher categories, 1202 in the General Service category and 144 in the Maintenance and Operatives Service category.

The year 1989 was the fifth consecutive year of zero real growth in the Agency's Regular Budget. The limitations inevitably resulting in the Agency's ability to respond to new demands placed on it by developments in the nuclear field have been somewhat alleviated by the provision of extrabudgetary contributions by Member States and growth in the Technical Assistance and Co-operation Fund. However, the 'zero real growth' conditions for the Regular Budget over such a long period have necessitated deferment of the acquisition of larger items of equipment, such as mainframe computer equipment. In searching for economies in the execution of programmes, managers were frequently forced to adopt, for example, unedited forms of publication of the results of experts meetings. In further attempts to reduce the cost of meetings, interpretation services were increasingly dispensed with. These trends are considered undesirable.

Organizational changes were made in the Departments of Technical Co-operation and Safeguards. To assist the Department of Technical Co-operation in responding to the increasing demands being placed upon it, the former Division of Technical Assistance and Co-operation was divided into two new Divisions — Technical Co-operation Programmes and Technical Co-operation Implementation. In the Department of Safeguards, the organizational modifications consisted of a regrouping of certain functions and a transfer of some human resources from support to operations work. Two other major measures to help increase the efficiency of the Department's activities were undertaken. The first was the development of safeguards implementation and evaluation criteria which will guide the Department from 1991 to 1995 in implementing the provisions of safeguards agreements. These criteria take into account recommendations made by the Standing Advisory Group on Safeguards Implementation (SAGSI) on long term guidelines for inspection goal attainment and current practices, criteria and policies.

The second measure related to the transfer of certain tasks arising from the co-ordination and implementation of Support Programmes to Member States. The administrative structure was modified to ensure that safeguards research and development projects carried out under the programmes are governed by priorities identified by the Agency.

The annual programming cycle for technical co-operation activities was replaced with a two year cycle. This longer cycle is designed to provide more time for the preparation of development projects and reflects the requirements of the increasingly complex activities which the Agency is being requested to undertake to assist Member States.

Regional co-operation, which in recent years has grown in importance in Asia and Latin America, took an important step forward in 1989 in Africa. Preparatory work relating to the establishment of a regional co-operative agreement for Member States in Africa was

successfully completed. The agreement, to be called AFRA, will come into force in 1990 and should lead to a significant augmentation of the Agency's technical co-operation efforts in this region.

A new international standing group (the International Radioactive Waste Management Advisory Committee (INWAC)) was established to provide advice and guidance on the Agency's entire waste management programme.

The Board of Governors approved the issuance of an Agency safety standard reflecting for the first time an international consensus on an approach for achieving safety in the underground disposal of high level radioactive waste. Entitled "Safety principles and technical criteria for the underground disposal of high level radioactive waste", the document in question contains principles and criteria that generally seek to ensure the long term radiological protection of man and the environment without burdening future generations with the costs or consequences of high level waste disposal.

Following a request from the USSR, arrangements began for a team of international experts under Agency auspices to carry out an assessment of the concept which the USSR had evolved to enable the population to live safely in areas affected by radioactive contamination following the Chernobyl accident and to evaluate the effectiveness of the steps taken in those areas to safeguard the health of the population.

In late 1989, there was a significant increase in requests to the Agency from eastern Europe for OSART, ASSET and other missions to assess and upgrade WWER nuclear plant operational safety, and work began on ways to meet this demand.

Following a suggestion made by the Governor from the USSR at the June Board to establish a Chernobyl Centre for International Research on Post-Accident Conditions, several meetings of interested parties took place. Eight technical areas were identified and a draft agreement between the Government of the USSR and the Agency and a model research project agreement were drafted for consideration.

A voluntary-offer safeguards agreement with China entered into force in September.

The Joint FAO/IAEA Division continued to collaborate with the FAO and the OAU in the primarily EEC funded Pan African Rinderpest Campaign (PARC). The Agency has established a network of laboratories in the region capable of conducting rinderpest sero-monitoring using an ELISA kit developed at the Seibersdorf Laboratories. The programme, which involves a total of 34 countries, has been operational for five years and has achieved eradication of the disease from over 15 countries, leaving only two presently infected.

Technical assistance was provided for a programme for the eradication of the New World Screwworm from North Africa. The Agency contributed equipment and technical expertise and training in containment and eradication by release of sterile insects. If implemented in time, this programme could help prevent massive loss of livestock and wildlife in Africa and the Mediterranean basin.

A further 23 developing countries concluded the Revised Supplementary Agreement concerning the Provision of Technical Assistance by the Agency, bringing the total to 64.

The Agency participated in the work of the Intergovernmental Panel on Climate Change (IPCC), providing factual information on the potential role of nuclear power in avoiding CO_2 emissions and on issues of nuclear safety. It also participated in the Ministerial Conference on Atmospheric Pollution and Climate Change, held in Noordwijk, Netherlands, and in preparatory meetings for the Conference on Action for a Common Future, held in Bergen, Norway, in May 1990.

The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture observed its 25th anniversary. The Director General joined the FAO Director General, Edouard Saouma, for special ceremonies in Rome in November. Both addressed the 25th Session of the FAO Conference.

The 25th anniversary of the founding of the International Centre for Theoretical Physics was celebrated on 31 October 1989 with a ceremony at which the Prime Minister of Italy, Mr. Giulio Andreotti, was the guest of honour.

At its thirty-third regular session, the General Conference approved by acclamation the nomination of Hans Blix of Sweden for a third four-year term of office as Director General of the Agency, effective from 1 December 1989.

Important nuclear related matters

The total installed nuclear power generating capacity in the world increased by about 3%, reaching 318 GW(e) by the end of the year. Nuclear power plants accounted for about 16.8% of the world's electricity generation in 1989, at the end of which there were 426 nuclear power plants in operation, representing an accumulated operating experience of around 5200 reactor-years.

During the year, 12 nuclear power plants came on line (in the German Democratic Republic (1), the Federal Republic of Germany (1), India (1), Japan (1), the Republic of Korea (1), Mexico (1), the United Kingdom (1), the USA (3) and the USSR (2)) and construction work started on five plants (in Japan, the Republic of Korea and the USSR). The Laguna Verde plant in Mexico is the first in that country, whereas the new plants in India and the Republic of Korea (the other developing countries mentioned above) are additional to already operating plants. Five reactors, with a total capacity of 1370 MW(e), were permanently shut down in the United Kingdom (2), the USA (1) and the USSR (2).

The inaugural meeting of the World Association of Nuclear Operators (WANO) was held in Moscow in May. The aims of the Association are to improve plant operational safety by strengthening existing links and co-operation among operators of the world's nuclear electricity plants. In June, a memorandum of understanding was signed between the Agency and WANO, establishing co-operation.

In the context of the Agency's work programme for 1991–1992, ten special advisory groups met over the course of the year to review various sectors of the programme. One of these was the Senior Expert Group on Nuclear Power, which met in November and examined the whole question of nuclear power, nuclear safety and radioactive waste management, together with the need for the associated public information activities.

The economics of nuclear power varies from country to country, depending on a number of technological and institutional factors. In the United Kingdom, during preparations for privatization of the public system of electricity generation and distribution, it was felt that nuclear power would not attract private investors. Hence, it was decided to exclude nuclear power for the time being. The matter will be reconsidered in 1994.

With the continued downward trend in uranium spot market prices, a number of uranium producers ceased production in 1988 and 1989.

The 1989 incident at the Vandellos nuclear power plant in Spain caused damage to safety systems which degraded the plant's defence in depth. However, it did not result in any external release of radioactivity, nor was there damage to the reactor core or contamination on the site.

Construction work was stopped on the Wackersdorf reprocessing project and co-operation was established between Federal German nuclear utilities, on the one hand, and Cogéma, in France, and British Nuclear Fuels plc, on the other, for additional spent fuel reprocessing at La Hague and Sellafield, respectively.

The USSR postponed indefinitely the completion of a reprocessing plant in Siberia with a planned annual throughput of some 1500 tonnes of heavy metal. The project had been about 30% completed.

Vitrification of high level wastes entered the industrial production phase with the active commissioning of a facility at La Hague, France, in June 1989.

Committees and Working Groups of the Board and General Conference

Pursuant to decisions taken by the Board of Governors in June 1988, the Committee on Assurances of Supply (CAS) Bureau held further consultations with CAS members on outstanding problems. The consultations, which took place in April, centred on: principles of international co-operation in the field of nuclear energy; and changes in the supply and demand situation of the world nuclear power market since 1980. A report on the consultations was presented to the Board in June 1989, and the Board asked the CAS Bureau to continue with consultations, in the light — inter alia — of updated information on the world nuclear power market situation, and to report to it again in June 1990.

As requested in 1988 by the General Conference, the Board of Governors re-established "an informal working group open to all Member States in order to continue to examine different proposals on the revision of Article VI of the Statute as a whole". The working group held four meetings during 1989, and its report was transmitted by the Board to the General Conference, which, in September 1989, requested the Board to re-establish the group once again with the same mandate. This the Board did early in October 1989, immediately after the 1989 session of the General Conference.

At the request of the General Conference, an intersessional working group of Member States' representatives considered ways and means of streamlining the General Conference's working practices. The report of the working group was approved by the Conference, and some of the group's recommendations were implemented already in respect of the Conference's 1989 session.

The General Conference adopted amendments to the arrangements for the financing of Agency safeguards. The amendments provided for the contributions of Member States qualifying for partial relief in respect of their assessments for the safeguards component of the Agency's Regular Budget to be increased by percentages equal to the price increase percentages on which the Regular Budget for each of the years 1990, 1991 and 1992 is based. These arrangements remain in force until the end of 1992.

The General Conference also requested the Board of Governors to establish an informal working group open to all Member States to consider various proposals for the financing of safeguards that could provide a long term solution. The working group was established by the Board at its meeting following the General Conference session, and it is expected to report to the Conference in 1990 on the progress made.

Resolutions adopted by the General Conference

In resolution GC(XXXIII)/RES/506, entitled "Israeli nuclear capabilities and threat", the General Conference requested the Director General "to consult with the States concerned in the Middle East area with a view to applying Agency safeguards to all nuclear installations in the area, keeping in mind the relevant recommendations contained in paragraph 75 of the report attached to document GC(XXXIII)/887 and the situation in the area of the Middle East, and to report on the matter to the Board of Governors and to the General Conference at its thirty-fourth regular session." The Director General was also requested to inform the Secretary General of the United Nations of this resolution.

In resolution GC(XXXIII)/RES/508, entitled "Measures to strengthen international co-operation in matters relating to nuclear safety and radiological protection", the General Conference invited the Board and the Director General inter alia " to maintain the emphasis given to nuclear safety and radiological protection". It requested the Board of Governors and the Director General to report on the implementation of this resolution to the thirty-fourth regular session of the General Conference.

In resolution GC(XXXIII)/RES/509, on the dumping of nuclear wastes, the General Conference expressed its appreciation to the Technical Working Group of Experts for the work done on the contents and structure of a code of practice for transboundary movements of radioactive wastes. It requested the Director General to continue to extend all facilities and assistance to the Working Group in order to facilitate its work. The Director General was also requested to report — through the Board of Governors — on the implementation of this resolution to the thirty-fourth regular session of the General Conference.

In resolution GC(XXXIII)/RES/510, on the Convention on the Physical Protection of Nuclear Material, the General Conference requested the Director General "to make available, within the Agency's existing budgetary resources, meeting room facilities and administrative and clerical assistance so that the parties to the Convention may hold, in 1990, a meeting of an open ended group of experts with the task of drafting recommendations for facilitating co-operation between the national authorities of Member States parties to the Convention in the implementation of the Convention."

In resolution GC(XXXIII)/RES/515, entitled "Plan for the production of low cost potable water", the General Conference requested the Director General to assess the technical and economic potential for using nuclear heat reactors in sea water desalination in the light of the relevant experience gained during the past decade, to assess the interest of potential beneficiaries and technology holders, and to report — through the Board of Governors — to the thirty-fourth regular session of the General Conference. It decided to include an item entitled "Plan for producing potable water economically" in the agenda for the thirty-fourth regular session of the General Conference.

In resolution GC(XXXIII)/RES/524, on South Africa's nuclear capabilities, the General Conference decided "to consider and take a decision on the recommendation of the Board of Governors contained in its report GC(XXXI)/807 to suspend South Africa from the exercise of the privileges and rights of membership of the Agency in accordance with Article XIX.B of the Statute at the thirty-fourth regular session of the General Conference." The Director General was requested "to continue to take all possible measures to ensure the full implementation of resolution GC(XXX)/RES/468 and to report to the thirty-fourth regular session of the General Conference in this regard."

Matters of special interest to the Agency discussed by the General Assembly of the United Nations

Several matters of interest to the Agency were discussed at the forty-fourth session of the General Assembly. In the debate that followed the presentation of the Agency's annual report for 1988, delegates indicated their broad support for the Agency, its safeguards system, its technical co-operation programme and its work in the field of nuclear safety. In its resolution on the report, the General Assembly affirmed "its confidence in the role of the Agency in the application of nuclear energy for peaceful purposes" and urged all States to co-operate in carrying out the work of the Agency.

The General Assembly adopted the following resolutions which are of direct interest to the Agency: the effects of atomic radiation (A/RES/44/45); the establishment of a nuclear-weapon-free zone in the region of the Middle East (A/RES/44/108); the implementation of the Declaration [on the Denuclearization of Africa] (A/RES/44/113 A); the nuclear capability of South Africa (A/RES/44/113 B); the prohibition of the dumping of radioactive wastes (A/RES/44/116 R); Israeli nuclear armament (A/RES/44/121); a United Nations Conference on environment and development (A/RES/44/228); and international co-operation in the field of the environment (A/RES/44/229).

Nuclear power

Nuclear power planning and implementation

Regional workshops

Two regional workshops (one week duration) were organized as a means of promoting the exchange of experience in the use of Agency methodologies for energy, electricity and nuclear power planning. The first workshop was organized under RCA and was held in China. The second was organized for countries in the Europe and Middle East and Africa regions, and was held in Cyprus.

Energy and economics

A technical co-operation project on energy and economics calculations with nuclear power options for Indonesia (Energy and Power Evaluation Programme (ENPEP) field test), conducted in co-operation between the Agency, the USA and Indonesia, was completed and a second field test of ENPEP was begun in Malaysia.

Support for developing Member States

In connection with the programme to provide support for developing Member States with existing nuclear power projects, especially project feasibility studies, infrastructure development planning, manpower planning and project management:

— Support continued to be provided to Iran in the review of the Bushehr nuclear power project.
— An advisory mission to Indonesia assisted the National Atomic Energy Agency (BATAN) in drawing up the terms of reference for a feasibility study on the introduction of nuclear power plants.
— Support was given to Romania in the preparation of commissioning procedures for a reactor cooling system.

Contracting and financing

Work continued on the preparation of a reference book on contracting and financing mechanisms for nuclear projects in developing countries (for publication in 1991).

Senior Expert Symposium on Electricity and the Environment

The first meeting of the Steering Committee for the Senior Expert Symposium on Electricity and the Environment (May 1991, Helsinki) was held. The symposium is being organized by the Agency jointly with CEC, CMEA, OECD/IEA, IIASA, OECD/NEA, UNECE, UNEP, the World Bank, WHO and WMO.

Publications

Series and No.	Title
IAEA-TECDOC-518	Energy and nuclear power planning study for Thailand
IAEA-TECDOC-528	Experience with WASP and MAED among IAEA Member States participating in RCA
Reference Data Series No. 1	Energy, electricity and nuclear power estimates for the period up to 2005
IAEA Yearbook 1989	Nuclear power and fuel cycle: Status and trends 1989
Technical Reports Series No. 298	Guidebook on research and development support for nuclear power

Training courses and seminars held

Course name	Location	No. of participants	Duration
RCA regional course on electricity generation system expansion planning (WASP)	Malaysia	31	6 weeks
Interregional course on electricity generation system expansion planning (WASP)	USA	31	9 weeks
RCA regional workshop on electricity generation system expansion planning	China	12	1 week
Regional workshop on electricity generation system expansion planning	Cyprus	32	1 week
National seminar for decision makers	Indonesia	50	2 days
Regional seminar for decision makers in Argentina, Brazil and Mexico	Argentina	17	3 days
RCA regional course on nuclear power project planning and implementation	Rep. of Korea	20	3 weeks

Nuclear power plant performance

Electricity generating costs

In a joint study with OECD/NEA/IEA, the comparative electricity generation costs of nuclear and conventional power plants were studied for plants to be commissioned in the period 1995–2000. The final report was published by the OECD. A technical document presenting more details of the studies for some Agency Member States has been drafted. The Agency has also co-operated with OECD/NEA in a study of means to reduce the capital costs of nuclear power plants. A study was initiated, jointly with the World Bank, on cost experience with nuclear and fossil fired power plants in some Member States.

PRIS

The main tool for assessing the technical and economic performance in nuclear plant construction and operation is the Agency's Power Reactor Information System (PRIS). On the basis of the results of a pilot project, which is the co-ordinated effort of the IAEA and the Nuclear Information Centre (NIC) of the Czechoslovak Atomic Energy Commission, and experience gained in external access to the database during an experimental period, PRIS was opened on 28 March 1989 for on-line access to IAEA Member States.

Information on PRIS

	1986	1987	1988	1989
Participating Member States	30	31	31	32
Organizations in Member States using direct access	—	—	—	23
Member States using direct access	—	—	—	20
Direct access users	—	—	—	39
International organizations using direct access	—	—	—	1[a]
On-line access hours by external users	—	—	—	105.63
Power reactors included in system	330	389	408	426
Reactor-years of experience reported (cumulative values)	3 411.3	3 792.3	4 194.3	4 645[b]
Data sets supplied on request	—	32	23	25

[a] WANO London Office.
[b] Estimates.

PRIS (cont.)

The micro-PRIS project started in the middle of 1989 on the basis of a research contract signed between the Agency and the NIC. The main objective is to make PRIS data available to Member States in a convenient format suitable for use on personal computers.

An Advisory Group Meeting was held to obtain advice on the possible improvements in PRIS. The group, comprising 11 experts from 7 Member States and WANO, made several recommendations to enhance the usefulness of PRIS. In particular, the need to intensify contacts with WANO was stressed.

Performance status and trends

Recognizing that there is a definite need to inform operators about the reasons for the good performance achieved by the world's best performing NPPs, the Agency published the results of a systematic search for good operational practices that contributed to improved plant performance. The publication included those practices which were identified through direct observations and documented by discussions with station management and staff during visits to selected nuclear power plants performing consistently above the world average. The publication was distributed to all nuclear utilities in Member States and to a significant number of individuals upon request. An Advisory Group meeting, held at the Barsebeck nuclear power plant in Sweden and attended by representatives of 10 utilities with extensive experience in NPP operation, advised the Agency to further pursue this activity with a publication focusing on good practices for effective plant outage management. In October, a consultants meeting assisted in the preparation of the envisaged publication.

Availability

Co-operation with the World Energy Conference (WEC) and the International Union of Producers and Distributors of Electrical Energy (UNIPEDE) continued in studies on the availability of electrical power plants, with the Agency contributing data on nuclear plants. Nuclear power plant availability continued to show improvements. The world average energy availability of nuclear power plants in 1988 was 72.1% (71.4% in 1987).

In-service inspection methods

A specialists meeting on experience and further improvement of in-service inspection methods and programmes on NPPs with particular emphasis on on-line techniques was organized in co-operation with the Czechoslovak Atomic Energy Commission. The aim of the meeting was to share experience and update information concerning in-service inspection methods and programmes of reactor equipment for defect detection, characterizing and sizing, using on-line and computerized techniques. Particular attention was devoted to problems of acoustic emission, ultrasonic and eddy current methods.

Residual stress studies

A specialists meeting on residual stresses in structural materials and components of nuclear power plants was held in Buenos Aires, Argentina. The aim of the meeting was to review the results of research work carried out in important problem areas. Great attention was devoted to problems of experimental techniques to determine residual stresses, the effect of residual stresses on materials properties and nuclear components. Since residual stresses are directly related to assurance of the lifetime of nuclear components and should be taken into account for remaining lifetime estimation, the conclusions and recommendations of the meeting will provide input to the Agency's programme on ageing and life extension of nuclear power plants.

Neutron irradiation embrittlement

A second progress reporting session was held to discuss the results of 14 national studies under a CRP started in 1988. The CRP, which is really a Phase III study on the general subject of neutron irradiation embrittlement of reactor pressure vessel steels, builds on Phase I (technology) and Phase II (steel composition and structure for controlling or classifying sensitivity to irradiation embrittlement).

Quality programme management

A manual on quality management for nuclear power plant operation was prepared and submitted for publication. The manual has been developed to assist plant managers in fulfilling their responsibility with regard to the control and supervision of the quality and the quality assurance activities in nuclear power plant operation. The document emphasizes quality objectives for the overall

Quality programme management (cont.)

performance of nuclear power plant operation and indicates the way in which a quality system based on quality assurance principles as established in the NUSS documents can be used by the managers to accomplish these objectives.

Grading of quality assurance requirements

A draft of a User's Manual on the grading of quality assurance requirements was reviewed and assessed by an Advisory Group meeting. The document is intended to provide guidance and illustrative examples for implementing a system by which applicable quality assurance activities are selected for nuclear power plant items and services. The manual will be completed during 1990.

Non-conformance and corrective actions

A User's Manual on quality assurance non-conformance and corrective actions was developed and approved for publication. The scope of the manual, which fully addresses the requirements in the governing NUSS documents, also covers non-conformance control measures and corrective action processes which would more generally assist users in developing good practices which contribute to improved performance in all areas of safety, reliability and economics.

Symposium on quality in plant operation

A symposium on quality in nuclear power plant operation, sponsored by Canada's nuclear industry in co-operation with the IAEA, was held in Toronto. It brought together senior executives, managers and technical experts from nuclear utilities around the world in an event which was especially significant in view of the formation earlier in the year of the World Association of Nuclear Operators (WANO).

The subject areas were selected with the objective of promoting the exchange of experience in the implementation of quality principles which contribute to safe, reliable and economic nuclear power plant operation. The papers presented both successful practices as well as breakdowns in good practice and described diverse approaches to achieving quality in operation. The meeting discussed the way nuclear energy could meet world demands for electricity in a manner that ensures public confidence in its safety and reliability. It is likely that the symposium will be repeated every two years in different countries.

Technical co-operation

Assistance to Member States in the field of quality assurance continued to be provided through 15 technical co-operation projects. Support was given in the form of training courses for development of qualified manpower, fellowships, expert services and equipment for non-destructive examination and in-service inspection techniques. Projects under way involved the following countries: Bangladesh, Bulgaria, China, Czechoslovakia, Egypt, Hungary, Indonesia, the Republic of Korea, Pakistan, Poland and Yugoslavia.

Quality standards for operating personnel

Within the framework of the project to review requirements for qualification standards and to promote international co-operation in the development of training simulators for nuclear power plant operating personnel, a questionnaire on procedures used for authorization and licensing of power plant operations personnel and on the accreditation of training programmes was sent to Member States.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Quality assurance for siting activities	Iraq	35	1 week
Regulatory inspection of mechanical equipment	China	34	2 weeks
Quality assurance for mechanical equipment	Poland	30	2 weeks
Quality assurance in nuclear power plant siting	Indonesia	40	2 weeks
Quality assurance for managers	Iran, Islamic Rep. of	18	1 week
Nuclear power plant equipment qualification	Yugoslavia	14	1 week
Quality assurance in research and development management	Rep. of Korea	40	2 weeks
Quality assurance during commissioning and operation	Rep. of Korea	15	2 weeks
Quality assurance programme and NDE techniques	Indonesia	67	2 weeks
PRIS on-line	Headquarters	8	1 week
National course on inspection of nuclear power plants	China	20–30	2 weeks
National seminar on pre-stressing systems containments	China	25–30	2 weeks
National course on interaction of grid and nuclear power plants. Parts I and II	China	20–25	3 weeks
National course on first refuelling operations	China	25–30	2 weeks
National workshop on operating regulations and techniques of operation of nuclear power plants	China	20–30	2 weeks
Regional workshop on in-service inspection of WWER type reactors	Hungary	8	1 week
Regional workshop on in-service inspection of codes and standards	Spain	14	1 week
Regional workshop on eddy current techniques	Yugoslavia	11	1 week
Regional workshop on pressure vessel examination	Spain	12	1 week
Regional course on inspection of steam generator tubes	Bulgaria	20–30	2 weeks
National workshop on commissioning procedures for moderator system	Romania	25–30	2 weeks
National workshop on commissioning procedures for primary transport system	Romania	20–30	3 weeks
National workshop on component control of CANDU plants	Romania	20–25	2 days
National workshop on reactor safety systems	Romania	25–30	2 weeks
National workshop on water chemistry and circuit cleaning	Romania	20–30	2 weeks
National workshop on preparation of operating instructions	Romania	20–30	2 weeks
National workshop on maintenance scheduling and instructions	Romania	20–30	2 weeks
National workshop on in-service inspection	Romania	20–30	2 weeks

Publications

Series and No.	Title
IAEA-TECDOC-498	Good practices for improved nuclear power plant performance
IAEA-TECDOC-507	Power reactor information system (PRIS)
IAEA-TECDOC-525	Guidebook on training to establish and maintain the qualification and competence of nuclear power plant operations personnel
Technical Reports Series No. 296	Regulatory inspection of the implementations of quality assurance programmes
Technical Reports Series No. 301	Manual on quality assurance for installation and commissioning of instrumentation, control and electrical equipment in nuclear power plants
Technical Reports Series No. 306	Guidebook on the education and training of technicians for nuclear power
Reference Data Series No. 2	Nuclear power reactors in the world
	Operating experience with nuclear power stations in Member States in 1988

Nuclear power system technologies

Special scientific meeting

In conjunction with the 33rd Session of the General Conference of the IAEA, a two-day special scientific meeting on the new generation of nuclear power plants was held in September in Vienna. Twenty-nine speakers from several member states and from the Agency gave presentations on: plant owners' requirements; the regulatory environment; suppliers' readiness; and the need for government support. The focus of the meeting was on initiatives already taking place or believed to be required to sustain or revive nuclear power as a viable energy option. These include technical factors such as simplification, standardization, improved safety features and economics. It was stressed that the introduction of a new generation does not only depend on technological progress but also on the changes to institutional factors, such as the establishment of a favourable licensing environment.

IWGFR

At its 22nd annual meeting, the International Working Group on Fast Reactors (IWGFR) reviewed current trends in national LMFBR development programmes. These include the conceptual design of a 1500 MW(e) unit by the European Fast Reactor Utilities Group, the construction of the two BN-800 units in the USSR, progress in construction of Japan's MONJU plant and the awarding of a contract from the United States Department of Energy for the design of a mid-size PRISM plant. In addition to the usual members of the Group (Member States directly involved in fast reactor development), the meeting was attended, at the request of the Governments of Argentina and Brazil, by an observer representing their joint fast reactor project.

LMFBR core mechanics code

Valuable results were achieved in the last stage of the CRP on intercomparison of LMFBR core mechanics codes, whose review report will be published in 1990. Good agreement has been obtained between 12 independent solutions using a variety of calculation methods for determining displacements and internal loads between deforming subassemblies. This good agreement has reinforced the confidence of participants in designing and understanding core support systems.

IWGATWR

In the framework of the International Working Group on Advanced Technologies for Water Cooled Reactors (IWGATWR), a report on the status of advanced technology and design for water cooled reactors, Part II (heavy water reactors), was published in 1989 (IAEA-TECDOC-510). The report is based largely upon submissions from Member States. It has been supplemented by material from presentations at a Technical Committee and Workshop held in Montreal, Canada. The report contains a description of development objectives for advanced heavy water reactors, related research and development programmes in Member States and a review of the current status of heavy water reactor plant technologies and designs.

Technical co-operation support for advanced reactors and reactor physics

Support was provided for a feasibility study on advanced reactors in the Republic of Korea. A short list of advanced reactor types was selected for detailed evaluation by using previously established criteria. This resulted in a proposal to participate in an international passive plant programme and an outline for undertaking additional national research and development activities. The Agency assisted Indonesia to acquire software and hardware for preparing necessary reactor physics calculations for their research reactors.

IWGGCR

At its 8th meeting, the International Working Group on Gas Cooled Reactors (IWGGCR) reviewed the status of national GCR programmes and recommended activities for the Agency's future programmes. One of the major recommendations was to consider the establishment of an international demonstration plant project, similar to the ITER project. It was pointed out that there was an increasing international interest in gas cooled reactors, in particular in the concept of small modular HTGRs due to their specific safety features, their simple technology and their broad application potential. The Agency has received several inquiries about the technological status of the GCRs and their application from Member States, who are assessing and evaluating this technology.

Seismic qualification

As part of the technical information exchange activities of the IWGGCR, a specialists meeting on the seismic behaviour of gas cooled reactor components was held. Approaches to the seismic qualification of components, various seismic analysis methods and the capabilities of the several available test facilities were discussed. The specialists recommended that the Agency could take a lead role in guiding the development of a simplified approach for seismic qualification based on experiments and confirming analyses already performed.

HTGR

Support was given to the feasibility study on the introduction of HTGRs in China.

Fusion research and engineering

A series of consultations with leading scientists and representatives of laboratories were organized in 1989 on the usefulness of tokamak oriented laboratory and training courses in the field of fusion research, especially for scientists from developing countries. The Boris Kidrič Institute (Yugoslavia) offered to organize such a training laboratory.

A new technical co-operation project named "Startup and Organization of Discharge in the NOVILLO Tokamak" at the National Nuclear Research Institute, Mexico, was approved. The goal is to provide a modern fusion laboratory with a middle scale tokamak for conducting experimental research which will also benefit education, science and technology in the country. The NOVILLO team is now co-operating with the Institute of Plasma Physics, University of São Paulo, Brazil, which operates a similar tokamak, and contact has been established with Atomenergoexport, USSR, with a view to acquiring equipment through the Agency.

Superconducting magnets

The development of superconducting materials and magnets is an important prerequisite for magnetic confinement systems, and intensive efforts have been devoted worldwide to bringing these technologies into practice. High temperature superconductors recently discovered might provide an additional option, although it will take considerable time for them to meet the requirements for a fusion power system. A Technical Committee meeting was held in Japan to discuss these possibilities. The meeting recommended that the Agency assist in the co-ordination of large test facility utilization for superconducting magnet development and convene a workshop on the engineering problems of superconducting materials.

Diagnostic methods

Interesting results were achieved in the CRP on advanced diagnostic development which were reported at a meeting in Berlin. Among the participants of this CRP are plasma physics groups from Argentina, China, Czechoslovakia, the German Democratic Republic, Hungary and India. The aim of the CRP is the development of two advanced diagnostic methods (lithium beam and X ray tomography) that can be used on various fusion devices.

International Thermonuclear Experimental Reactor (ITER)

Support for the ITER project continued through the ITER Secretariat and the IAEA–ITER liaison officers. Two ITER Council meeetings were organized in Vienna and a new form of publication was established — the ITER Documentation Series (five such documents were published during 1989 by the IAEA). In general, the conceptual design activities have progressed well and the ITER team has arrived at a single conceptual design for a facility that could achieve the established objectives. ITER is expected to fully confirm the scientific feasibility and to address the technological feasibility of fusion power. At the last ITER Council meeting very satisfactory progress was announced. Results in the design and performance related areas of physics are confirming the ITER concept and enlarging the ITER database. During 1989, the ITER Council chartered a Working Party on Ways and Means, whose purpose is to identify means to attain the objectives of the ITER co-operation — a formal commitment by the Parties to construct the machine. Possible arrangements for the legal framework of the next ITER phase (Engineering Design Activities) have been examined. As one of the possible options, an agreement was proposed for work under Agency auspices and under conditions which could be acceptable to Agency management. ITER would be an experimental facility, intermediate between the current large tokamak experiments and a fusion reactor capable of reliably producing electric power. Its construction and operation could serve as a pilot project in international collaboration.

***Nuclear Fusion* Journal**

In co-operation with the Division of Publications, earlier production of each monthly issue of *Nuclear Fusion* was achieved. The subscription price of the journal was increased at the beginning of the year (and again at the end, bringing the total rise to around 50%). It was agreed to simultaneously reduce the subscription price for individuals whose institutes already subscribe to the journal.

'World Survey'

All material for the sixth edition of the Supplement "World Survey of Activities in Controlled Nuclear Fusion Research" was collected, sorted and corrected. Preparation for publication in 1990 was started.

CRPs established in the current year

Subject	No. of years	Participating institutions
Acoustic signal processing for the detection of boiling or sodium water reaction in LMFBRs	3	7
In-core fuel management benchmark for PHWRs	3	6
Validation of physics calculations for low enriched HTGRs	4	Expected: 6

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	In-core fuel management code package validation for LWRs	1991	8
1988	Safe core management with burnable absorbers in WWERs	1991	9
1988	Establishment of thermal database	1993	4
1988	Development of advanced diagnostics for edge plasma studies	1990	7
1989	Lifetime predictions for plasma facing components	1992	8

Publications

Series and No.	Title
IAEA-TECDOC-495	Robotics and remote maintenance concepts for fusion machines
IAEA-TECDOC-510	Status of advanced technology and design for water cooled reactors: heavy water reactors
IAEA-TECDOC-514	Seismic analysis of liquid metal fast breeder reactors
IAEA-TECDOC-519	Research using small tokamaks
IAEA-TECDOC-534	Pellet injection and toroidal confinement
IWGFR-68	Signal processing techniques for sodium boiling noise detection
IWGFR-70	Status of national programmes on fast breeder reactors
IWGGCR-18	High temperature metallic materials for gas cooled reactors
IWGGCR-19	Design requirements, operation and maintenance of gas cooled reactors
IWGGCR/20	Status of national programmes on gas cooled reactors
IWGATWR/2	Status of national programmes on advanced water cooled reactors
Proceedings Series (3 volumes)	Plasma physics and controlled nuclear fusion research 1988
Technical Reports Series No. 297	Flow induced vibrations in liquid metal fast breeder reactors
ITER Documentation Series No. 2	ITER definition phase
ITER Documentation Series No. 3, Vols 1 and 2	ITER concept definition
ITER Documentation Series No. 4	Passive control of vertical instabilities in ITER
ITER Documentation Series No. 5	Design point selection for an ignited ITER

Nuclear fuel cycle

Nuclear fuel cycle in the 1990s

A comprehensive analysis was made of the dominant trends in the world nuclear fuel cycle and on the Agency's projects, with emphasis on expected changes and corresponding probable directions for international co-operation in the 1990s ("Nuclear Fuel Cycle in the 1990s and Beyond the Century: Some Trends and Foreseeable Problems", Technical Reports Series No. 305).

Resources of nuclear raw materials

Supply-demand analysis

As part of the programme to improve the long term availability and diversity of the supply of raw materials for nuclear fuel to meet world demand, a careful analysis was performed on the status and future of the uranium industry.

'Red Book'

The new version of the 'Red Book', a joint report of the IAEA and OECD/NEA, was sent to press. The main statistical data on uranium resources, exploration, production and demand in WOCA are included in this report, which provides Member States with a reliable basis for strengthening their national capabilities for long term projections and planning of nuclear power development. Within the framework of this activity two meetings were convened: a consultants meeting on methods for estimation and economic evaluation of undiscovered uranium endowment and resources, and a Technical Committee meeting on assessment of uranium resources and supply. The principal results of these meetings, besides the exchange of information, included the following: the 'club' of the Red Book contributors was expanded, thus increasing the quality and comprehensiveness of the uranium situation analysis; and the manuscript of an instruction manual aimed at providing geologists and policy makers with methodology and recommendations on the estimation of undiscovered resources was prepared for publication.

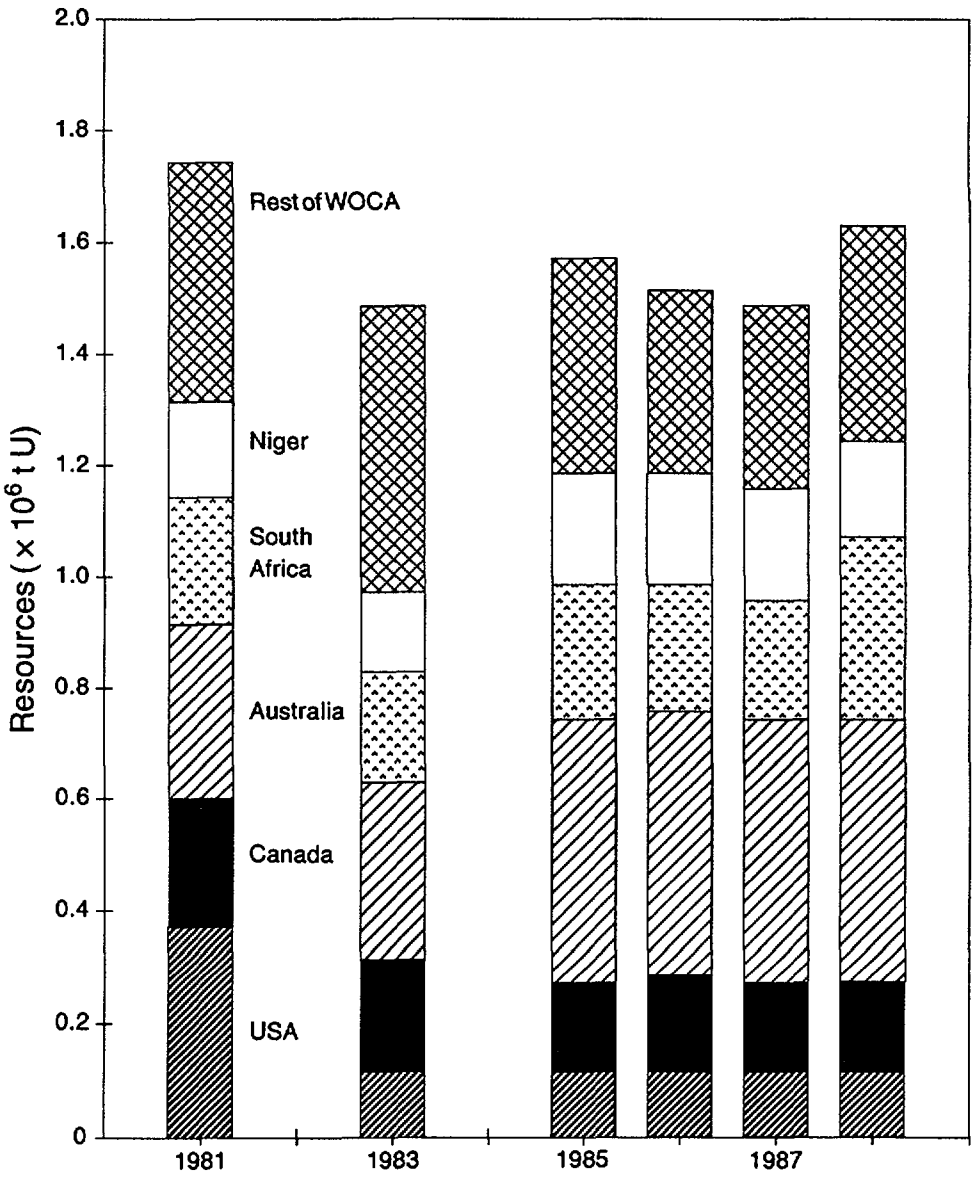
Wider use of exploration techniques and data

A number of projects were carried out in support of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency. An internal report on airborne gamma spectrometric measurements of the fallout over Sweden after the nuclear accident at Chernobyl was issued, and three other reports ("Airborne Gamma Ray Spectrometric Surveying", "The Use of Gamma Ray Data to Define the Natural Radiation Environment" and "The Construction and Use of Calibration Facilities for Radiometric Instruments") were submitted for publication. These documents make an important technical contribution to the above mentioned convention and the nuclear liability conventions, because they provide Member States with an effective and reliable tool for rapidly determining the radiation situation in the event of an accident and with justified data for the assessment of changes in the natural (pre-accident) radiation environment. At the same time, these studies are directed to the systematization and updating of uranium exploration data and are considered as part of joint activities with UNESCO/IGCP on International Geochemical Mapping.

Anniversary of uranium discovery

As part of the programme on the characteristics and recognition criteria of the world's uranium deposits and in conjunction with the 200th anniversary of the discovery of uranium, a Technical Committee meeting on uranium resources and geology in Europe was held in Czechoslovakia with the participation of specialists from 15 countries and one international organization. It was stressed

REASONABLY ASSURED RESOURCES RECOVERABLE AT $80/kg U

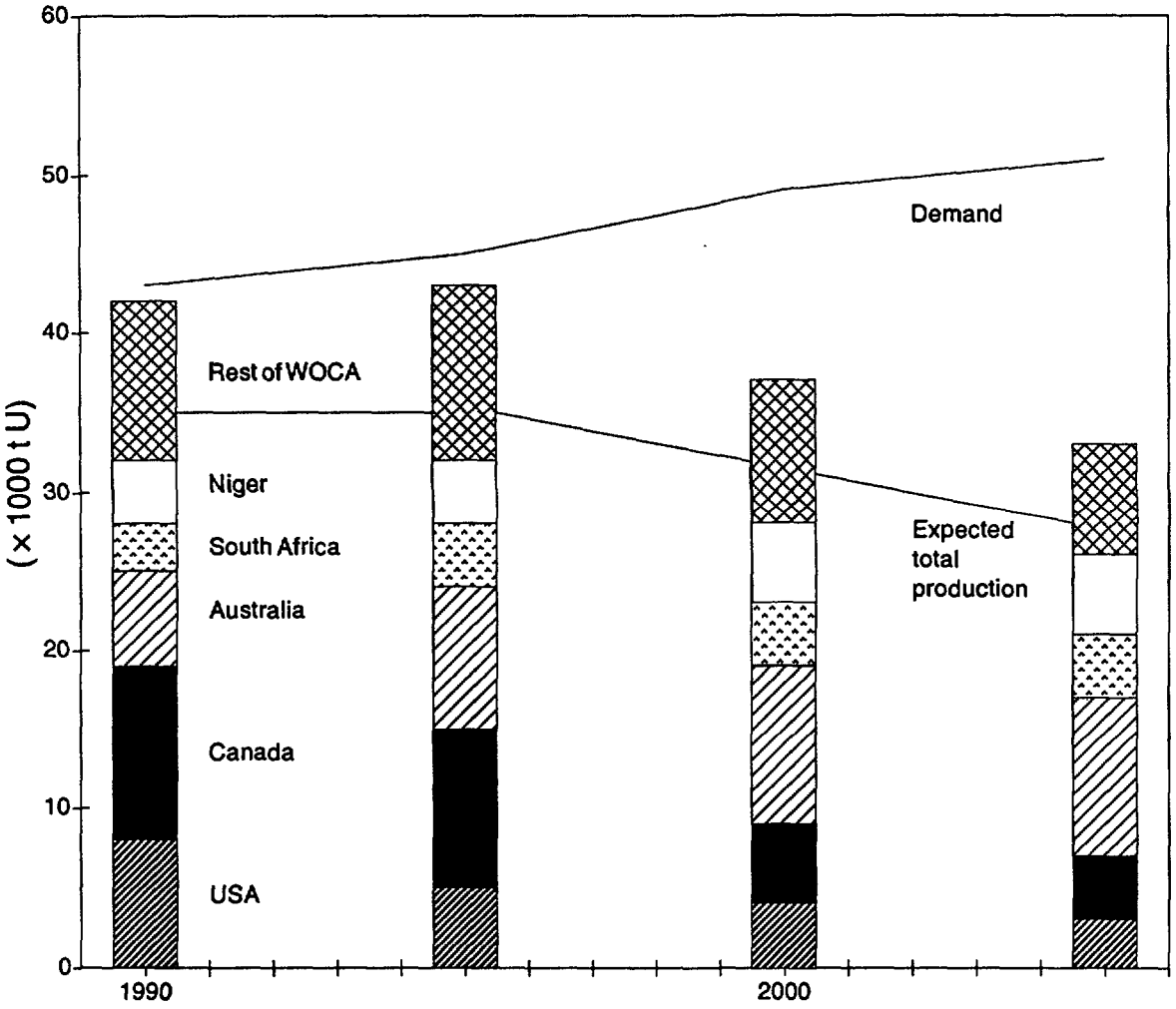


Anniversary of uranium discovery (cont.)

"that efforts to preserve the knowledge and technology developed during the peak of uranium activities of the mid-1970s should be made". A number of specific recommendations were made during the meeting, including:

(a) the formation of a working group of experts from 17 European countries for the preparation of a uranium metallogenic map of Europe;
(b) the formation of a group to define the factors controlling uranium enrichment and localization in and around Hercynian granitic rocks in Europe;

WOCA URANIUM SUPPLY AND DEMAND PROJECTION



Production capacity, existing and committed, $80/kg U

Anniversary of uranium discovery (cont.)

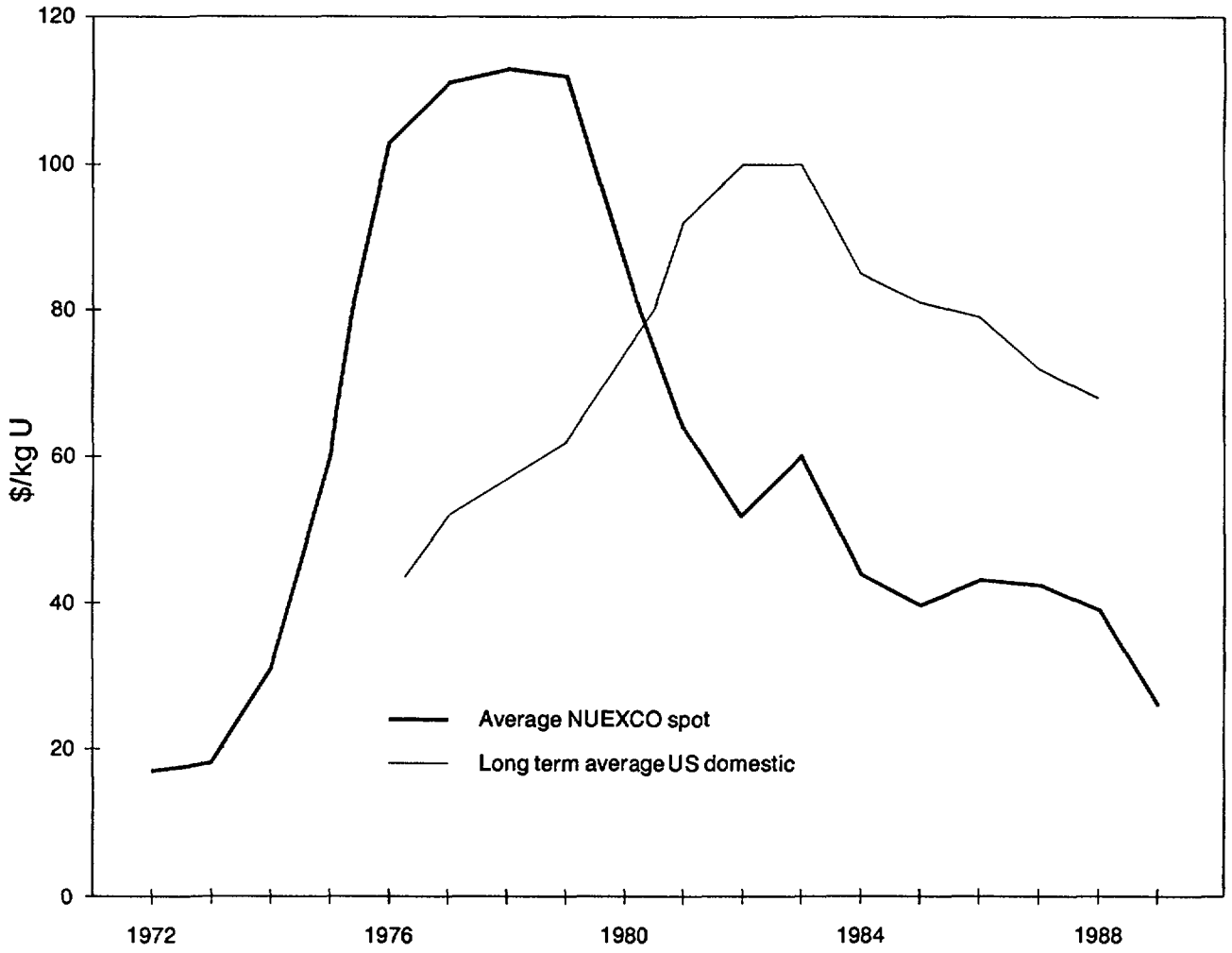
(c) a reduction in the uncertainties related to the absolute dating of uranium mineralization in Europe.

The meeting stressed once again the important role of the Agency as the only remaining international organization which co-ordinates and stimulates co-operative efforts on uranium geology.

Technical co-operation support

Thirty-four technical co-operation projects on uranium exploration and resource development in 33 countries were supported.

VARIATION IN SELECTED URANIUM PRICES
(at current money values)



Publications

Series and No.	Title
IAEA-TECDOC-500	Uranium resources and geology of North America
	Uranium Newsletter No. 3
Panel Proceedings	Uranium deposits in magmatic and metamorphic rocks
Panel Proceedings	Metallogenesis of uranium deposits

Processing of nuclear and reactor materials

Guidelines on nuclear fuel cycle activities

As part of the programme to assist in the planning and implementation of nuclear fuel cycle activities in developing countries, an Advisory Group meeting was held. The group recognized that the infrastructure for the processing of nuclear materials is inadequate in many developing countries and no Agency publication exists covering the planning and organization of activities in the whole of the fuel cycle. It was decided that a guidebook should be prepared to assist developing nations who have embarked on or are contemplating embarking on a nuclear power programme. The guidelines will take account of the experience gained by countries already engaged in fuel cycle activities and will be sufficiently flexible to accommodate the various circumstances likely to be found in developing countries. Such important factors as strategy and considerations of technology transfer, resource availability and financing of capital investment will be analysed. A final report should be available in 1991.

Safety, economics and environmental aspects of nuclear material processing

Particular attention was paid to projects specifically oriented towards the safety, economics and environmental aspects of nuclear material processing. The proceedings of a Technical Committee meeting on technical, environmental and economic aspects of in situ leaching of uranium were issued as IAEA-TECDOC-492. Material from the meeting on the economics of low enriched uranium, attended by experts from 40 Member States and covering a wide range of topics connected with the uranium market, conversion and enrichment, and U and Pu recycling, was submitted for publication. These documents provide important information on a number of key questions relating to the further development of the nuclear industry, with emphasis on problems of an international character. Part of this programme is a project on the environmental consequences of the operation of nuclear fuel cycle facilities; this was started in 1989 and is focused on the preparation of a handbook on the environmental impact of nuclear fuel cycle facilities to the public.

Publications

Series and No.	Title
IAEA-TECDOC-492	In situ leaching of uranium: technical, environmental and economic aspects
IAEA-TECDOC-533	Recovery of uranium from phosphoric acid

Reactor fuel design, fabrication and performance

IWGFPT

In accordance with its mandate, the International Working Group on Water Reactor Fuel Performance and Technology (IWGFPT) reviewed Agency activities since 1988, national programmes, major non-Agency meetings and completed on-going and planned co-ordinated research projects, and defined the topics and priorities for Agency meetings in the period 1990–1993.

Recycling of plutonium and uranium

As part of the programme on new trends in nuclear power, a Technical Committee meeting on the recycling of plutonium and uranium in water reactor fuel was held in Cadarache with the participation of 60 experts from 11 countries and 2 international organizations. The meeting recognized that although additional investigations are needed, MOX technology is at an adequate level of development to permit immediate industrial scale use and this concept is considered increasingly attractive for many countries with a developed nuclear programme.

Corrosion of Zr based alloys

A Technical Committee meeting on the fundamental aspects of the corrosion of Zr based alloys in a water reactor environment and a special study on irradiation corrosion mechanisms for Zr alloys in high temperature water were initiated in connection with the programme to guarantee a high level of reliability for fuel that is intended to be used in improved utilization schemes, such as extended burnup or Pu recycle, or under improved plant operational conditions, such as increased capacity factor on load following. The discussions showed that despite the many years of experience of Zr behaviour there is much scope for further experimental study of corrosion mechanisms.

WREBUS

The technico-economic aspects of an improved scheme of fuel utilization are being analysed by a group of experts within the framework of the Water Reactor Extended Burnup Study (WREBUS), which is focused primarily on the assessment of the economics of high burnup operation (in particular on the fuel cycle costs of the equilibrium cycle) and some technical aspects related to fuel design and manufacture, including safety and environmental issues. It is planned to complete WREBUS in 1990.

Post-irradiation examination

A CRP on examination and documentation methodology for water reactor fuel was completed in 1989. It resulted in the preparation of a Guidebook on "Non-Destructive Examination of Water Reactor Fuel", which will provide Member States with information on modern methods and techniques for post-irradiation examination of fuel elements and on a proper methodology for the documentation of irradiated fuel performance.

Technical co-operation

Ten technical co-operation projects were supported in eight countries in the areas of nuclear fuel fabrication, nuclear fuel and materials study, nuclear fuel development, simulation of radiation damage and research reactor modernization.

A new type of activity related to the provision of technical co-operation with developing countries was started. As a demonstration project, an experimental programme on grain size determination in Zr alloys is being organized for laboratories in a number of developing countries under the guidance of a 'supervisory expert group'. The host laboratory (Siemens AG UB KWU) will provide assistance in the definition of the techniques, procedures and the methods of work and the evaluation of data and results.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Water chemistry control and coolant interaction with fuel and primary circuit materials in water cooled power reactors (WACOLIN)	1991	20

CRPs established in the current year

Subject	No. of years	Participating institutions
Technology and performance of integrated burnable absorbers for water reactor fuel	5	9

Publications

Series and No.	Title
IWGFPT/31	Burnup determination of water reactor fuel
IWGFPT/32	Water reactor fuel element computer modelling in steady state, transient and accident conditions
Technical Reports Series No. 299	Review of fuel element developments for water cooled nuclear power reactors
Technical Reports Series No. 305	Nuclear fuel cycle in the 1990s and beyond the century: some trends and foreseeable problems

Spent fuel management

Storage practice

Spent fuel storage remains of crucial importance in many countries and the Agency paid special attention to the improved technology of storage with emphasis on safety and reliability. As part of the programme, the second edition of the Guidebook on Spent Fuel Storage was finalized in 1989. Like the first edition, this Guidebook is expected to be widely used in Member States for critical comparison of various existing approaches and for justification of national solutions. In-depth analyses of current storage practices and future trends are presented in a publication "Spent Fuel Management: Current Status and Prospects" as well as in the proceedings of a meeting on methods for expanding spent fuel storage facilities; these contain information on the optimization of rod consolidation technology, high density racks, transport/storage casks, silos and vaults.

Reliability of materials

As part of the programme on the long term behaviour of materials in aggressive and radiation environments, a Technical Committee meeting was held on improvements in structural materials resistance to chemical degradation and irradiation in the back end of the nuclear fuel cycle. In addition to the presentation of papers, three panel discussions were held on specific aspects of corrosion in reprocessing, spent fuel storage and waste management. The meeting evaluated the current status of knowledge and identified areas for future studies. A specific project on the behaviour of structural materials under irradiation, with emphasis on heterogeneous processes, was started to help fill the existing gap in the understanding of irradiation effects.

Safety of spent fuel storage

Within the framework of the Special Nuclear Safety Programme, a report on safe spent fuel storage and possible ways to avoid fuel damage was prepared. This report contains information which can be used to assess releases of radioactivity following low probability beyond design basis accidents in spent fuel pools and gives examples of safety aspects of current design practice for spent fuel storage facilities. Special attention is given to at-reactor pools which are located close to the reactor core and are thus in principle sensitive to accidents.

Economics of spent fuel storage

A book on "Methodology on Economics of Spent Fuel Storage" was finalized in 1989. The rationale for this project was the realization that comparisons of the relative economics of different spent fuel storage options are often improperly presented because an appropriate methodology has not been used. The present book, which is planned for publication in 1990, has been written to inform professionals involved in the development and implementation of policy decisions and should act as an aide-mémoire for experienced nuclear engineers.

Emergency response

In support of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, an analytical report on the management of severely damaged nuclear fuel and related waste has been elaborated. This addresses on-site, post-accident management leading to a stable condition with the aim of gaining absolute control over damaged fuel and related waste and ensuring there is no longer the potential for uncontrolled release to the environment.

Feasibility of by-product utilization

A study on the recovery and utilization of Pd, Rd and Ru was finalized. This gives a comprehensive basis for proper considerations of the options for noble metals recovery and for the formulation of appropriate strategies. The report should be of interest to policy makers in the nuclear fuel cycle and in waste

Feasibility of by-product utilization (cont.)

management, as well as those interested in the processing and applications of Pd, Rh and Ru in non-nuclear industries. A study on the separation and utilization of Cs and Sr was started with the participation of experts from Belgium, the Federal Republic of Germany, Japan, the United Kingdom, the USA and the USSR, with the aim of evaluating the market potential of Cs and Sr and analysing the market importance of nuclear by-products.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Behaviour of spent fuel and storage facility components during long term storage (BEFAST-II)	1991	16

Publications

Series and No.	Title
IAEA/NENF/NF-89-2	Advanced structural materials for nuclear fuel cycle facilities
IAEA-TECDOC-487	Spent fuel management: Current status and prospects
IAEA-TECDOC-513	Management of spent fuel from research and prototype power reactors and residues from post-irradiation examination of fuel
Technical Reports Series No. 308	Feasibility of the separation and utilization of ruthenium, rhodium and palladium from high level nuclear wastes

Radioactive waste management

INWAC

The International Radioactive Waste Management Advisory Committee (INWAC) was formed in recognition of the importance placed on radioactive waste management by Member States and the need to formalize programme advice provided to the Agency in this field. INWAC's charter is to provide guidance on the scope, content and direction of the waste management programme (including technical, safety, environmental and regulatory aspects). The Committee is composed of representatives from 18 Member States so as to provide expertise in all the major areas of waste management. The first meeting of INWAC took place in April.

The Committee strongly endorsed proposals for the establishment of a new integrated series of Radioactive Waste Safety Standards (RADWASS) publications to facilitate international harmonization of safety related activities in this field. INWAC also recommended an increase in the level of support to technical co-operation with developing Member States and the development of the Waste Management Database (WMDB).

RADWASS

At a time when there is considerable public concern over the radioactive waste issue, the Agency is regularly requested to assist Member States by providing evidence that radioactive waste can be managed safely. Specifically, there is a need to demonstrate that a degree of international harmonization exists on safety related aspects of waste management. While this has already been achieved to some extent through publications in the IAEA Safety Series, a more formalized and dedicated series of documents, possibly similar to those of the Nuclear Safety Standards (NUSS) programme, has been planned after endorsement of the idea by INWAC. The advantages of the new arrangement will be in achieving greater visibility and status for safety related publications in providing a coherent and well defined structure and in increasing international harmonization in approaches to radioactive waste management. RADWASS could be valuable to Member States with mature waste management programmes as an 'international reference point' for use in the development of regulations and codes of practice or as support for existing national standards and criteria. For Member States just beginning to formulate their waste management plans, RADWASS could be used as the basis for national regulations and guidance.

WMDB

In response to the needs of Member States for information on the status and trends of activities in the field of radioactive waste management, efforts have been initiated to develop and implement a computer based information system. The database will contain the latest information available on: low level waste, intermediate level waste, alpha and high level waste, spent sealed sources, spent fuel designated as the final waste form and wastes from decommissioning activities. A questionnaire was forwarded to all Member States requesting information about the above waste types. The replies to the questionnaire will form the basis of the system, which will be used to meet various report requirements and to respond to Member States' enquiries.

WATRP

In response to requests from Member States for peer reviews of their waste management programmes, the Agency established the Waste Management Assessment and Technical Review Programme (WATRP). At the request of Member States, the Agency will organize teams of international experts to provide peer reviews and assessments of aspects of national waste management

WATRP (cont.)

programmes under the auspices of the Agency. This service is directed toward Member States with established waste management programmes and offers the opportunity for independent review and thus may be seen as a mechanism for increasing reliability and confidence in national programmes. Such peer reviews will assist organizations in Member States in the evaluation of the technical, safety, operational and/or performance features of waste management systems planned or in operation. The first review under this programme was conducted at Harwell, United Kingdom, to evaluate the UK Nirex Ltd R&D programme on deep repository post-closure safety and site assessment.

WAMAP

The Agency's Waste Management Advisory Programme (WAMAP) conducted eight missions to developing Member States seeking advice on the establishment of national waste management programmes and information on feasible technical solutions to specific waste management problems with due recognition of regional resource limitations. Special emphasis was given to demonstrating technology for immobilizing spent radiation sources in selected Member States. WAMAP has now completed missions to 23 Member States since its inception in 1987.

Public understanding of waste management issues

An Advisory Group meeting was held to review the draft of a 'Source Book' being developed to provide basic information on subjects of waste management of concern to the public.

Transboundary movements of radioactive wastes

The issue of transboundary movements of radioactive wastes, principally for the purpose of disposal, has attracted public concern following various reports of the dumping of toxic and hazardous wastes in developing countries. The subject was discussed at the 32nd Session of the IAEA General Conference and a resolution (GC/XXXII/RES/490) was adopted to develop an agreed code of practice for international transactions involving radioactive wastes. At the request of the United Nations Environment Programme (UNEP), the Agency also prepared a document on the Effects on the Environment of the Dumping of Nuclear Wastes, and forwarded it to UNEP for submission to its Governing Council. The document was presented to the forty-fourth session of the United Nations General Assembly as a part of the Report of the Secretary General.

Publications

Series and No.	Title
	Waste management research abstracts No. 19
	Waste management assessment and technical review programme (WATRP)

Handling, treatment, conditioning and storage of radioactive waste

Spent sealed radiation sources

The problem of the disposal of sealed radiation sources no longer in use exists in all Member States and there is the potential for serious radiation hazards from inadvertent exposure to these sources. As part of the Agency programme for dealing with this problem a practical guidance document was produced to provide Member States with advice on all aspects of spent sealed source handling and disposal.

WPSF

Since the needs for waste processing and storage are very similar in most developing countries, the Agency is producing a standardized technological solution to the problem. A centralized Waste Processing and Storage Facility (WPSF) is being designed which will be appropriate for the management of wastes in the majority of developing countries with no nuclear power plants. Detailed plans will be available from the Agency for the construction of such a facility. The aim of the project is to maximize safety in waste processing and storage using simple but reliable technology, while keeping costs at modest levels.

Alpha bearing waste conditioning technology

A series of matrix materials and technologies currently available for conditioning of alpha bearing waste are described in the final draft of a Technical Reports Series publication entitled "Conditioning of Alpha Bearing Wastes". The waste forms must satisfy long term disposal requirements to inhibit release of long lived radionuclides to the biosphere.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1984	Performance of solidified high level waste forms and engineered barriers under repository conditions	1989	11
1987	Use of inorganic sorbents for liquid radioactive waste treatment and backfill for underground repositories	1991	12

Training courses and seminars held

Course name	Location	No. of participants	Duration
Management of radioactive wastes with regard to radioisotope applications	Germany, Fed. Rep. of	30	4 weeks

Publications

Series and No.	Title
IAEA-TECDOC-521	Retention of iodine and other airborne radionuclides in nuclear facilities during abnormal and accident conditions
Proceedings Series	Management of low and intermediate level radioactive wastes 1988
Technical Reports Series No. 291	Design and operation of off-gas cleaning systems at high level liquid waste conditioning facilities
Technical Reports Series No. 292	Design and operation of off-gas cleaning and ventilation systems in facilities handling low and intermediate level radioactive material
Technical Reports Series No. 294	Options for the treatment and solidification of organic radioactive wastes
Technical Reports Series No. 302	Treatment of off-gas from radioactive waste incinerators

Radioactive waste disposal

Standards and Guides

The Agency has continued to review and summarize current technological and other developments related to waste disposal, and in 1989 documents were being prepared for publication on the sealing of underground repositories, and on a state of the art review of underground disposal. In the regulatory area, guides were being prepared on siting, design and construction of an underground repository and on qualitative acceptance criteria for high level waste forms in geological repositories. During 1989, the Board of Governors approved for publication Safety Series No. 99, which sets out internationally harmonized criteria for the safe underground disposal of high level wastes.

Symposium on safety assessment of radioactive waste repositories

The Agency, together with the CEC and OECD/NEA, sponsored a symposium in Paris on the safety assessment of radioactive waste repositories. The meeting was structured with mainly invited review papers so that the proceedings, when they are published early in 1990, will represent the state of the art in this important subject area. Papers presented at the symposium demonstrated that techniques for repository safety assessment are well developed and that there is confidence in these techniques. The symposium also showed the considerable degree of harmony in the approaches being used by different Member States.

Application of exemption principles

Work continued in the implementation of the 1988 international consensus on exemption principles. Current projects include application of the principles to the recycle of slightly contaminated materials and to the wastes arising from the use of radioisotopes in hospitals and research establishments.

London Dumping Convention

The Agency continued to fulfil its appointed role as adviser to the London Convention on the Prevention of Marine Pollution by preparing a number of reports related to marine waste disposal, on risk comparison, comparisons of land versus sea disposal options, the effects on man of low level radiation and an inventory of marine disposals. These are intended for presentation to the Convention at its 1990 meeting.

Environmental model validation; the VAMP project

A study on the validation of environmental transfer models (VAMP) which seeks to utilize the environmental information from the Chernobyl release has continued. As a means of improving international co-ordination in this subject area the CEC agreed in 1989 to co-sponsor the study. Currently, four working groups have been established within the VAMP project: terrestrial, urban, aquatic and multiple pathways.

ILMR

As in previous years, the International Laboratory for Marine Radioactivity at Monaco (ILMR) has assisted laboratories engaged in the analysis of different man-made and natural radionuclides in materials of marine origin by producing reference samples and executing intercomparison exercises on a worldwide basis. As a consequence of these exercises, more than 100 laboratories in developed and developing countries have been able to assess the accuracy of their radiological results.

Status of marine intercomparison exercises — radionuclides

Sample description	Status	No. of participants
IAEA 306 Baltic sediment	Completed 5/89	84
IAEA 307 Seaplant	Completed 5/89	66
IAEA 308 Seaweed	Completed 5/89	67
IAEA 352 Tuna fish	Distributed 7/89	74
IAEA 358 Mediterranean sediment	Sample prepared 12/89	
IAEA 367 Coral sediment	Sample prepared 10–12/89	
IAEA 368 Coral sediment	Sample prepared 10–12/89	

UNSCEAR project

ILMR, in co-operation with UNSCEAR, is compiling inventories of radionuclides in the marine environment. The first report from this effort was published as IAEA-TECDOC-481 in 1988 and contained estimates of the global ocean inventories of ^{14}C, ^{90}Sr, ^{137}Cs, $^{238,239+240}Pu$, ^{210}Po, ^{210}Pb and ^{226}Ra. Chapters are currently being prepared for the second report of this series that will include the global inventories of ^{3}H, ^{60}Co, ^{99}Tc, ^{129}I, ^{237}Np, ^{241}Am, and U, Th, Pa and Ac isotopes.

In-service training

In co-ordination with the Department of Technical Co-operation, ILMR staff provided laboratory and field training in marine radioactivity techniques to five individuals who were granted fellowships for differing periods of time during the year. The IAEA Fellows represented institutions in Cuba, Malaysia, Portugal, Thailand and Turkey.

Marine radioactivity dose assessment

To generate a co-operative report on global and/or regional dose assessment from radionuclides in the marine environment, the first meeting of the CRP "Sources of Radioactivity in the Marine Environment and their Relative Contributions to Overall Dose Assessment from Marine Radioactivity" was held. The participants agreed to focus their efforts on obtaining global data for ^{137}Cs and ^{210}Po, the two most important radionuclides from the standpoint of human dose assessments from ingesting marine foodstuffs. Intercalibration materials have been issued to all participants with instructions to complete the analyses by the time of the next meeting.

Radionuclides in food chains

Both laboratory and field studies were carried out in co-operation with Denmark, France, the United Kingdom and the USA in order to trace patterns and transfer of both natural and artificial radionuclides in different marine food chains. Measurements in samples from several oceanographic cruises in the Atlantic have demonstrated that certain natural radionuclides are useful tools for determining the types of food ingested by deep sea crustaceans and fish. In other laboratory and field experiments using organisms from the Mediterranean and Baltic regions, it was found that bioaccumulation rates and food chain transfer of artificial radionuclides vary with environmental parameters as well as biological and ecological factors. Additional focus was placed on the role played by microscopic unicellular algae in introducing radionuclides into the base of the food chain. These studies have highlighted the usefulness of laboratory tracer experiments to simulate what would occur in a contaminated environment, and are furnishing important data for interpreting radionuclide concentration factors routinely measured in Member States' environmental monitoring programmes.

Global measurements of vertical flux of radionuclides

A series of oceanographic cruises were undertaken in the Mediterranean, the North Atlantic near Iceland, and a Norwegian fjord to measure the downward vertical flux and oxidation state changes in artificial radionuclides at different depths in contrasting marine environments. The cruise to Iceland, a collaborative effort with the Federal Republic of Germany, was part of the first phase of the Joint Global Ocean Flux Study (JGOFS), an international effort aimed at determining global fluxes of carbon and other materials, in particular, information which has a direct bearing on the 'greenhouse effect'.

Field work off the Norwegian coast took place in collaboration with scientists from Norway, Sweden, the United Kingdom and the USA, with the goal of comparing transuranium nuclide oxidation states in heavily anoxic waters in Framveren Fjord with those previously measured in the less anoxic Black Sea.

In the Mediterranean, three major cruises were undertaken within the French DYFAMED flux programme, which also forms part of the JGOFS network.

ILMR's decade long activities in the North Pacific under the US sponsored VERTEX Flux Programme officially terminated and analyses of the final seasonal samples are now in process.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Geochemistry of long lived transuranic actinides and fission products	1991	10
1988	Validation of models for the transfer of radionuclides in terrestrial, urban and aquatic environments (VAMP)	1992	17
1989	Sources of radioactivity in the marine environment and their relative contributions to overall dose	1992	17

Publications

Series and No.	Title
Technical Reports Series No. 304	Natural analogues in performance assessments for the disposal of long lived radioactive wastes
Safety Series No. 92	Principles for the establishment of upper bounds to doses to individuals from global and regional sources
Safety Series No. 96	Guidance for regulation of underground repositories for disposal of radioactive wastes
Safety Series No. 99	Safety principles and technical criteria for the underground disposal of high level radioactive wastes
Safety Series No. 100	Evaluating the reliability of predictions made using environmental transfer models

Decontamination and decommissioning of nuclear installations

Cleanup after an accident

The programme established in the aftermath of the Chernobyl accident to provide guidance and to review the state of the art in large area cleanup methodologies and technologies is almost completed. A report providing a technological overview on the subject has been published (Technical Reports Series No. 300) and three reports on overall operational planning, the safe transport and disposal of large volumes of contaminated wastes, and the rehabilitation, decommissioning and disposal of nuclear facilities after an accident, are in the process of publication.

International guidance

In the area of nuclear power plant decommissioning, the Agency is contributing to the establishment of internationally accepted procedures and criteria. A Safety Guide has been completed on the regulatory process in decommissioning, and a further publication on monitoring for compliance with unrestricted release criteria is in preparation.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Decontamination and decommissioning of nuclear facilities — Phase II	1992	18

Publications

Series and No.	Title
IAEA-TECDOC-511	Decontamination and decommissioning of nuclear facilities
Technical Reports Series No. 293	Factors relevant to the recycling or reuse of components arising from the decommissioning and refurbishment of nuclear facilities
Technical Reports Series No. 300	Cleanup of large areas contaminated as a result of a nuclear accident

Food and agriculture

General

The programme in food and agriculture is operated by FAO and the IAEA through the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. As shown below, there were 39 CRPs in progress in 1989 and 12 regional and interregional training courses were conducted together with fellowship training. The Agricultural Biotechnology Laboratory at Seibersdorf continued to provide backup research for these programmes. Technical supervision was provided for 233 technical co-operation projects in 67 Member States involving nuclear techniques in agriculture.

Soil fertility, irrigation and crop production

***Azolla* biofertilizer**

A CRP evaluating the availability of N from *Azolla* biofertilizer was completed. The results have shown that *Azolla* is as good as urea as a N source for rice on a per kg N basis. Additionally, *Azolla* floating on the surface of flood water improved the efficiency of chemical N fertilizers. The results of the programme will be published.

Laboratory activities

The Soils Unit of the Agency's Laboratories Seibersdorf continued to provide support services to programmes in soil fertility. To this effect, the Unit provided 54 person-months of training to 12 fellows on the use of isotope techniques in soils research. Development activities continued on the use of DNA probes and other molecular biology techniques to monitor the fate of inoculants in field soils (as an effective extension of recently completed CRPs on pasture and grain legumes). Research in the laboratory focused on the identification of genotypes of crop and tree species with high efficiency of uptake and utilization of soil resources. Eighteen scientific articles emanating from this research were submitted for publication during the year.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1985	The use of isotopes to improve yield and N_2 fixation of grain legumes in Latin America	1990	9
1985	Evaluation and calibration of nuclear techniques compared with traditional methods in soil–water studies	1990	7
1986	The use of nuclear and isotopic techniques to improve crop production on salt-affected soils	1991	10

CRPs established in the current year

Subject	No. of years	Participating institutions
Increasing and stabilizing plant productivity in low phosphate and semiarid and subhumid soils of the tropics and subtropics	5	11
Improvement of yield and N_2 fixation of grain legumes with the aim of increasing food production and saving N fertilizer in the tropics and subtropics of Asia	4	10
Assessment of irrigation schedules of field crops to increase the effective use of water		

Training courses and seminars held

Course name	Location	No. of participants	Duration
The use of isotope and radiation techniques in studies on soil–plant relationships with emphasis on nitrogen fixation (interregional)	IAEA Seibersdorf	21	6 weeks
The use of isotope and radiation techniques in studies of biological nitrogen fixation and soil–plant nutrition (regional)	Senegal	15	4 weeks
The use of isotopes and radiation techniques in studies on soil–plant relationships with special emphasis on trees (regional)	Malaysia	21	4 weeks

Plant breeding and genetics

Technical assistance and training

The main concern has been to provide plant breeders in Member States with the genetic resources badly needed for developing better cultivars — which form the basis of all improvements in agriculture, horticulture and forestry. Particularly in regard to improved resistance to pathogens and insect pests, 'natural resources' cannot satisfy the needs for high intensity agriculture. Moreover, consumers and processors are demanding certain new properties hitherto unavailable. To help meet the needs in this area, support has been given to over 60 technical co-operation projects. In addition to training courses, over 50 fellowships have been awarded.

Improvement of rice and other cereals

Participants in the second research co-ordination meeting on improvement of rice and other cereals through mutation breeding in Latin America reported important results relating to resistance to disease *(Pyricularia oryzae)* and earliness (more than two weeks) found in mutated progeny in Brazil, Colombia and Guatemala. In Chile, two mutants of wheat showed an increase in tolerance to phosphorus deficient volcanic soils. Breeders from Brazil selected from mutated progeny semidwarf and semierect mutants of wheat which are a good source for improvement in other countries of Latin America.

Laboratory activities

The Plant Breeding Unit of the Agency's Laboratories continued to support the Agency's programmes through providing one interregional and one regional training course, facilities and guidance to ten fellowship trainees, a service to Member States in the mutagen treatment of seeds (500 samples) and through research and development work on mutation breeding techniques using nuclear and related biotechnological methods. Thirteen scientific articles were published in the course of the year.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1986	The use of induced mutations in connection with haploids and heterosis in cereals	1990	17
1987	Improvement of rice and other cereals through mutation breeding in Latin America	1991	16
1987	Use of induced mutation and in vitro culture techniques for improving crop plant resistance to diseases	1991	12
1989	Improvement of basic food crops in Africa through plant breeding including the use of induced mutations	1993	18
1989	Mutation breeding of oil seed crops	1993	14
1989	Improvement of root and tuber crops in tropical countries of Asia	1993	7
1989	In vitro mutation breeding of bananas and plantains	1993	9

Training courses and seminars held

Course name	Location	No. of participants	Duration
Induction and use of mutations in plant breeding	IAEA Seibersdorf	18	6 weeks
Use of mutants for different cross-breeding programmes	Costa Rica	10	3 weeks

Publications

Series and No.	Title
IAEA-TECDOC-496	Improvement of crops in Africa through the use of induced mutations
Proceedings Series	Plant domestication by induced mutation
Kluwer	Current options for cereal improvement

Animal production and health

Reproductive efficiency of livestock

Radioimmunoassay (RIA) methods continued to be successfully employed by counterpart institutions in developing Member States to complement traditional measures of reproductive performance and assist farmers in identifying and subsequently resolving constraints to reproduction in indigenous ruminant livestock. Four CRPs on this topic, involving 74 participating institutions, were completed during the course of the year and the results prepared for publications in the Panel Proceedings Series. All of these programmes focused on indigenous breeds and types of animals kept by smallholder farmers in tropical and subtropical countries, and in addition to work on cattle, sheep and goats, included studies on camelids in Latin America and water buffaloes in Asia. These programmes demonstrated the great genetic diversity which exists with respect to the productivity of indigenous animals and highlighted the significance of inadequate nutrition and poor management practices (e.g. heat detection, rearing of calves) as major constraints to reproductive performance. In many instances, reproductive efficiency and productivity were improved by supplementary feeding at strategic periods and by better methods for heat detection and rearing of offspring.

Nutrition of ruminant livestock

Counterpart institutions were assisted in improving the infrastructure required for pursuing research on the use of conventional and isotopic methods for measuring the nutritional status of animals and the feeding value of pastures, forages and agroindustrial by-products. An Advisory Group meeting on feeding strategies for improving the productivity of ruminant livestock, held in Vienna, concluded that the future direction of research in this area should consider the 'farming system' rather than simply the feeds available and their nutritional value. Efforts will therefore now concentrate on identifying and resolving priority constraints to productivity; this is likely to include a great deal of on-farm research (in conjunction with some institutional research) and account taken of reproductive, productive, management, husbandry, disease and economic factors in the system in addition to an effort to monitor the nutritional status of the animal from a limited number of metabolic parameters.

Diagnosis and control of livestock diseases

In connection with the objective of establishing or improving the infrastructure required for diagnosing and controlling viral, bacterial and parasitic diseases of livestock, efforts have concentrated on: (i) the production and distribution of standardized FAO/IAEA immunoassay kits for rinderpest, brucellosis and trypanosomiasis; (ii) development of immunoassay kits for bovine coronavirus, bovine rotavirus, rift valley fever, Newcastle disease and infectious bovine rhinotracheitis; (iii) updating of bench manuals for the foregoing diseases and (iv) development of improved computer software systems for analysing immunoassay test results in counterpart laboratories.

Laboratory activities

The Animal Production Unit of the Agency's Laboratories continued to play an integral part in the various activities. For instance, the Unit provided facilities and guidance to 12 fellowship trainees and scientific visitors, produced standardized RIA kits (400 000 assay units) for measuring the hormone progesterone in livestock milk and blood and monitored the accuracy of these kits in the 60 end-user laboratories through an external quality control service. The Unit dispatched ELISA kits (equivalent of 520 000 assay units) for the diagnosis of 5 major livestock diseases. Research and development activities concentrated on the validation of new kits for measuring hormones, disease antigens/antibodies, and nutritional metabolites using nuclear and related techniques.

Distribution of FAO/IAEA kits for hormone measurements and animal disease diagnosis

	1985	1986	1987	1988[a]	1989[a]
Number of Member States supplied	12	23	40	50	58
Number of assay units	180 000	600 000	850 000	1 200 000	920 000

[a] Includes some Member States of FAO, but not of IAEA.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Regional network for Latin America on animal diagnosis using immunoassay and labelled DNA probe techniques	1991	15
1987	Serosurveillance of rinderpest and other diseases in Africa using immunoassay techniques	1991	24
1988	Strengthening animal reproduction research in Asia through the application of immunoassay techniques	1993	13
1988	Improving the productivity of indigenous African livestock using radioimmunoassay and related techniques	1993	18
1988	Development of feeding strategies for ruminant livestock in areas of fluctuating nutrient supply	1992	19
1988	Improving the diagnosis and control of trypanosomiasis and other vector-borne diseases of African livestock using immunoassay methods	1993	13
1988	Strengthening animal disease diagnosis in Asia through the application of immunoassay techniques	1991	12

CRPs established in the current year

Subject	No. of years	Participating institutions
Development of feed supplementation strategies for improving ruminant productivity on smallholder farms in Latin America through the use of immunoassay techniques (ARCAL III, Phase II)	5	19

Publications

Series and No.	Title
Panel Proceedings Series	Nuclear techniques in the study and control of parasitic diseases of livestock

Insect and pest control

Fruit flies

Fruit flies are major pests in most of the developing world, damaging fruit and vegetables and limiting exports. The problem is becoming more serious because of a lack of post-harvest treatments. The effectiveness of the sterile insect technique (SIT) in the eradication of the Mediterranean fruit fly (medfly) from Mexico and the melon fly from Okinawa, Japan, has resulted in an increased interest in SIT. Algeria, the Libyan Arab Jamahiriya, Morocco and Tunisia have initiated a regional technical co-operation programme to determine the feasibility of medfly eradication.

Tsetse flies

Tsetse flies are a major pest to livestock in Africa, transmitting animal trypanosomiasis. Large areas of Africa remain undeveloped because of the tsetse fly. These flies may be controlled or even eradicated by integrating SIT with other methods of fly suppression. This integrated approach in tsetse fly control is being developed by the Agency.

New technology for controlling vegetable and cotton pests

In a CRP, control of the diamondback moth, *Plutella xylostella*, and the pink bollworm, *Pectinophora gossypiella*, is being stressed. The diamondback moth is a major vegetable pest in most developing countries, while the pink bollworm is a major worldwide pest of cotton. Rearing technology, sterilizing rates and field studies are being conducted on these pests using the F-1 sterility technique.

New World Screwworm

The New World Screwworm, *Cochliomyia hominivorax*, has become established in the Libyan Arab Jamahiriya. This insect attacks all warm blooded animals, particularly livestock and wildlife, and could be devastating to Africa and the Mediterranean Basin. The IAEA has joined FAO in developing plans to eradicate this pest using SIT. Eradication plans have been developed and a training course given for the North African countries. The North African strain has been examined and has been found sexually compatible with the strain that is being reared in Mexico. The logistics and technical requirements for shipping sterile flies from a factory in Mexico are being explored.

Laboratory activities

The Entomology Unit of the Agency's Laboratories remains at the forefront of SIT research and development. This has resulted in improved rearing technology for the medfly with reduced production costs. Medfly trapping systems are being improved and standardized. A strain of medfly that can be separated by sex using pupal colour has been developed and field tested with good results. A strain of medfly in which all females can be killed at a very early stage by heat is being developed. This major breakthrough will allow the rearing of males only, thus reducing rearing costs and making the medfly SIT programme even more effective.

Presently, seven species of tsetse flies are being reared at the Laboratory. Automation of feeding systems is being developed. Hybridization of various subspecies of tsetse flies results in sterility. DNA probes and isoenzyme studies at Seibersdorf have shown no major changes in colonized strains. There have been major improvements in the rearing of *Glossina fuscipes fuscipes* and *Glossina brevipalpis*.

A technology based on F-1 sterility was tested as a new approach to insect control. It is similar to SIT, but the insects are irradiated at a substerilizing dose and the F-1 generation is sterile. This technique may be more effective than SIT for certain insects.

Laboratory activities (cont.)

As part of the Agency's programme, tsetse flies and medflies are regularly shipped to research centres in Africa, Europe and the Middle East.

Training continues to be a major aspect of the Unit's work; five fellowship trainees, seven scientific visitors and one cost-free intern were trained in various components of SIT during the year.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Standardization of medfly trapping for use in sterile insect technique programmes	1992	9
1987	Radiation induced F-1 sterility in Lepidoptera for area-wide control	1992	10
1988	Laboratory and field evaluation of genetically altered medflies for use in sterile insect technique programmes	1993	12
1989	Development of practices for area wide tsetse eradication or control with emphasis on the sterile insect technique	1994	9
1989	Genetic engineering technology for the improvement of the sterile insect technique	1994	7

Training courses and seminars held

Course name	Location	No. of participants	Duration
The sterile insect technique for fruit fly control (training course and seminar)	Guatemala	75	3 weeks

Agrochemicals and residues

General

This programme has developed and introduced radiotracer aided research methods suitable for evaluating local agricultural practices, for identification of priority problems related to pesticide use and for monitoring pesticide residues in the agricultural environment. Four CRPs were completed on pesticide residues in livestock products and stored grain, pesticide residues bound to biological substrates, and the behaviour of persistent pesticides in the tropics. Radiotracer techniques have successfully served as powerful research tools in programmes aimed at improving the safety and efficacy of pesticide chemicals. These programmes aimed at evaluating local agricultural practices involving the use of pesticide chemicals. They have identified practices which lead to acceptable residue levels in foodstuffs and practices which should be modified or changed since they can cause health hazards to consumers or can pose a threat to the agricultural environment.

Symposium on Environmental Effects Following a Major Nuclear Accident

An FAO/IAEA/UNEP/WHO International Symposium on Environmental Effects Following a Major Nuclear Accident was held in Vienna, Austria, from 16 to 20 October 1989. The symposium was attended by nearly 250 participants from 49 countries and 7 international organizations. Sixty-seven papers and 53 posters were presented. The objective of the symposium was to review the extent and magnitude of environmental contamination that would arise after a large injection of radioactive materials, and the methods employed in monitoring, assessing and limiting the short and long term effects on the environment, agriculture and human health.

The main points relating to possible future activities in the present area were:

— Difficulties in defining the significance for neighbouring countries of a radioactivity release in connection with early notification;
— Difficulties in quantifying general levels for intervention criteria — various criteria were applied at Chernobyl;
— International harmonization in the definition and use of terms, units and accident terminology;
— The need for international agreement on radioactivity levels in food and feedstuffs that do not constrain free movement in international trade;
— The need for improved international guidelines and economic provisions to assist countries affected by a transboundary release;
— The recognition of the importance of 'hot particles' for the thorough understanding of radionuclide behaviour in the environment, and for the assessment of health risk for exposed individuals.

Agrofungicides in food plants

Studies carried out during a CRP on agrofungicides in food plants have confirmed the frequent presence of fungicide residues on raw agricultural commodities, treated according to local practices, some leading to unacceptable levels of the highly toxic derivative ethylenethiourea (ETU). Washing commodities prior to processing can remove substantial quantities of residues and is an invaluable practice in reducing the final residue at the point of consumption. ETU increases during cooking are consistent (up to 400%). Data indicate that ETU is present in commercial preparations in varying quantities (up to 4%) depending on the supplier. The quantity increases on storage, particularly in open packages under warm and humid conditions.

Laboratory activities

The Agrochemicals Unit of the Agency's Laboratories supported the various programmes by conducting research and development activities on: environmentally stable control release (CR) formulation of insecticides against tsetse flies; CR formulation of herbicides against weeds in rice–fish ecosystems. The Unit distributed a number of ^{14}C labelled CR formulations of herbicides to counterpart laboratories in the developing world. Four fellows received training in nuclear techniques in agrochemicals and residues during the year. Four research publications were written by the Unit in 1989.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1983	The use of isotopes in studies of pesticides in rice–fish ecosystems	1991	7
1984	Radiotracer studies of fungicide residues in food plants	1989	9
1986	Biological activity and bioavailability of bound pesticide residues using nuclear techniques	1991	8

CRPs established in the current year

Subject	No. of years	Participating institutions
Development of controlled release formulations of pesticides utilizing nuclear techniques	5	9
Radiotracer studies of behaviour of DDT in tropical environments	5	12
Radiotracer studies to reduce or eliminate pesticide residues during food processing	5	12

Publications

Series and No.	Title
IAEA-TECDOC-494	Radioactive fallout in food and agriculture

Food preservation

ICGFI

The mandate of the International Consultative Group on Food Irradiation (ICGFI) has been extended for another 5 years, i.e. from 1989 to 1994. In accordance with its mandate, ICGFI monitored and assessed global developments in food irradiation, provided information and advice to member countries and FAO, IAEA and WHO in the areas of safety assurance of the process, legislation, techno-economic feasibility, training, international trade and public information. A task force meeting was convened to establish criteria that foods, produced according to good manufacturing practices, could be further processed by various methods including irradiation. The report of the meeting has been published by WHO on behalf of ICGFI. Training workshops were held on irradiation to ensure hygienic quality of food in Latin America (Argentina), the use of irradiation to reduce post-harvest food losses (India and Israel). Eight Provisional Guidelines on specific applications of food irradiation were published. A Food Irradiation Process Control School (FIPCOS) for training operators and food control officials was established and convened separately for the two target groups. The Governments of Belgium, Brazil, Côte d'Ivoire, Ecuador, Ghana, Greece and the United Kingdom became members of ICGFI, bringing the total membership to 33.

Asian Regional Project

The successful completion of the second phase of the Asian Regional Cooperative Project on Food Irradiation (RPFI Phase II), funded by the Australian Government, has resulted in an effective transfer of food irradiation technology to local industries in several countries in the region. As a result, Bangladesh, China, India, Indonesia, the Republic of Korea, Pakistan, Philippines and Thailand have approved a number of irradiated foods for consumption in recent years. Commercial/demonstration irradiators have been or are being built in Bangladesh, China, the Republic of Korea, Malaysia, Pakistan, Philippines, Thailand and Viet Nam.

Recognizing the contribution of food irradiation to economy and the health of the population in the region, UNDP agreed to fund further collaborative work of the RPFI with emphasis on process control and acceptance of the technology (RPFI Phase III), starting January 1990.

Developments leading to practical application of food irradiation

	1985	1986	1987	1988	1989
Number of countries which have approved irradiation of one or more food items	29	31	34	37	37
Number of countries which irradiate food for commercial purposes	15	20	21	22	24
Number of demonstration/commercial irradiators used for treating food for commercial purposes	17	22	28	33	47

Note: A total of 7 demonstration/commercial irradiators available for food processing are under construction in Bangladesh (1), Côte d'Ivoire, France (2), Poland (1), the USA (2) and Viet Nam (1). These irradiators will be in operation before the end of 1990. In addition, a number of existing irradiators used for sterilizing medical and pharmaceutical products in China, Denmark, Malaysia, Pakistan, the United Kingdom and the USA could be used for processing certain types of food when the regulations permit and when there is a demand.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1986	Use of irradiation as a quarantine treatment of food and agricultural commodities	1990	12
1986	Food irradiation programme for Latin American countries	1990	10
1987	Use of irradiation to control infectivity of food-borne parasites	1991	12
1989	Food irradiation programme for Middle East and European countries	1993	14
1989	Application of irradiation techniques for food processing in Africa	1993	9

CRPs established in the current year

Subject	No. of years	Participating institutions
Analytical detection methods for irradiation treatment of food (ADMIT)	5	15
Asian Regional Co-operative Project on Food Irradiation: process control and acceptance (RPFI Phase III)	4	15

Training courses and seminars held

Course name	Location	No. of participants	Duration
ICGFI workshop on use of irradiation to reduce post-harvest food losses in Asian countries	India	15	2 weeks
ICGFI workshop on use of irradiation to reduce post-harvest food losses in Africa, Latin America and developing European countries.	Israel	16	2 weeks
International Facility for Food Irradiation Technology (IFFIT) general training course on food irradiation	Netherlands	20	5 weeks
ICGFI food irradiation process control school (FIPCOS) — for operators/plant managers of irradiation facilities	Canada	14	2 weeks
ICGFI food irradiation process control school (FIPCOS) — for food inspectors and food control officials	Netherlands	20	2 weeks
ICGFI training workshop on use of irradiation to ensure hygienic quality of food in Latin America	Argentina	25	2 weeks

Publications

Series and No.	Title
IAEA-TECDOC-490	Safety factors influencing the acceptance of food irradiation technology
Proceedings Series	Acceptance, control of and trade in irradiated food
Technical Reports Series No. 303	Radiation preservation of fish and fishery products

Human health

Nuclear medicine

Technical co-operation

Scientific and other support was provided to 52 new technical co-operation projects in the area of nuclear medicine.

Developing indigenous resources and strengthening the capabilities for nuclear medicine services in developing countries

Two major projects, one for RCA and the other for ARCAL, are in progress to promote the use of bulk reagents for the radioimmunoassay of thyroid related hormones in place of imported ready-to-use kits. Sixteen countries in the Asia and the Pacific region and 14 countries in Latin America are participating in the programme. The use of this technology has reduced the cost of the assays by a factor of 5–10 and stimulated the production of the requisite reagents indigenously, some by sophisticated biotechnology methods.

Co-ordinated research programmes on quality control and preventive maintenance of nuclear medicine equipment were set up for the Asia–Pacific, Latin American and African regions. The emphasis is on developing suitable protocols for the increasingly complex instruments currently used. Many of the training activities are held in collaboration with other international organizations such as WHO and UNIDO. A revised version of IAEA-TECDOC-317 was prepared for publication; it includes new chapters on the quality control of computers and newer imaging devices.

Promoting the use of nuclear medicine applications relevant to the needs of the developing countries

In vitro nuclear techniques are being developed for the diagnosis of communicable diseases such as malaria, schistosomiasis and tuberculosis through a series of CRPs. Two seminars were held, one in India and the other in Brazil, on nuclear techniques in communicable diseases. Selected papers from these seminars will be published as an IAEA-TECDOC. An article in the IAEA Yearbook describes this programme in detail. A new method of immobilizing the reagents on a solid phase by radiation increases the shelf life of many of the biological reagents used in these assays.

A CRP to evaluate the diagnostic efficacy of nuclear imaging of the liver was concluded. The work is described in a 'liver imaging atlas', which is meant to assist doctors in the problems encountered in the interpretation of liver imaging. A second phase of this CRP was also initiated; in this, the diagnostic efficacy of liver imaging will be compared with that of ultrasound imaging.

Publications

Series and No.	Title
IAEA-TECDOC-501	Atlas of liver imaging
IAEA-TECDOC-509	Radioimmunoassay data processing program for IBM PC computers
Proceedings Series	Dynamic functional studies in nuclear medicine in developing countries

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Radioaerosol inhalation imaging for the diagnosis of respiratory diseases in the developing countries (RCA)	1990	11
1987	Promotion of the optimum use of bulk reagents for RIA of thyroid related hormones (ARCAL)	1990	14
1987	Immunodiagnostic techniques for the quantitative determination of circulatory and urinary parasite derived antigens in human schistosomiasis	1990	10
1987	Immunodiagnosis of tuberculosis (RCA)	1991	9
1988	Care and maintenance of nuclear medicine equipment in Asia	1991	9
1988	Development and field applications of nuclear techniques for malaria research and control	1991	11
1988	Development of diagnostic reagents for communicable diseases using radiation processing techniques	1991	6

CRPs established in the current year

Subject	No. of years	Participating institutions
Evaluation of imaging procedures for the diagnosis of liver diseases — Phase II	3	10
Optimization of nuclear techniques for the survey of thyroid function of newborns in endemic goitre areas	3	9
Quality control and preventive maintenance of nuclear and related medical equipment in Africa	3	12
Quality control and preventive maintenance of nuclear medicine equipment in Latin America	3	12
Quality control of advanced nuclear medicine equipment in Asia	3	8
Immunodiagnosis of malaria	3	7

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on basic nuclear medicine	German Dem. Rep.	23	3 weeks
Optimum use of computers in nuclear medicine imaging	Australia	13	6 weeks

Applied radiation biology and radiotherapy

Radiation sterilization of medical supplies

Within the programme for promoting national health care services in developing countries, there has been recognition of the risk of patients contacting cross-infectious diseases resulting from an inadvertent clinical use of a non-sterile medical item. Indigenous technical skills and relevant research and development capabilities in developing countries on such aspects as the estimation of the microbiological burdens of local medical supplies and determination of their radiation response criteria, both essential for accurate sterilizing dose setting and the required level of sterility safety assurance, have been enhanced through training courses and by providing opportunities for developing country scientists to visit advanced laboratories and research institutions. Radiation sterilization processing has been adapted for use with medical disposables, such as syringes, needles, operating kits, cotton gauze and bandages, in Africa and the Middle East regions. Biological tissue graft implants, such as bone, nerve, fascia, dura, tendons, skin and amnion dressings for burn wounds, among others, have been successfully sterilized by gamma radiation in developing countries of the Asia and Pacific region and applied in reconstructive surgery. The guidelines document for Member States on the radiation sterilization of disposable medical products has been finalized, also incorporating comments from users and revisions. It has been sent for publication as an IAEA-TECDOC.

Radiation for improved fermentation

Radiation and radioisotope techniques have been developed to isolate improved mutants of microorganisms, capable of the fermentation of cassava starch, including the prospects for an enrichment of nutrient proteins and detoxification of cyanogenic linamarin contents. Twelve developing and developed Member States have co-ordinated research and shared technical know-how in the successful attainment of the above results. The improved radiation mutants have been further successfully applied in the pilot scale fermentation of cassava starch, with the defining of the optimized environmental factors being relevant for their potential success in a larger operation. Use of current molecular genetic techniques has also been attempted in some of the investigations to further improve those selected mutants. The final results of the CRP have been submitted for publication as an IAEA-TECDOC to permit wider dissemination among Member States.

Biological dosimetry for radiation protection

Radiation induced chromosomal effects as implemented through a joint programme with the Division of Nuclear Safety have formed the basis of a 'biological dosimeter' for accurate quantitative estimation of in vivo absorbed radiation doses essential for radiation protection and risk assessment operations. Biological dosimetric criteria and standards as calibrated through the programme have been successfully applied in the radiological safety monitoring services of accidentally overexposed personnel in Member States, such as for the Goiânia accident cases in Brazil.

Radiation for sewage recycling

Radiation induced microbicidal effects, as well as other radiation microbiological and physical/chemical alterations of solids affecting the settling qualities, have been pursued in a project for feasibility studies for sewage treatment and for safe recycling as resources. Relatively low radiation processing doses, e.g. 3 kGy, have proved effective in imparting beneficial attributes, such as disinfection of pathogens, acceleration of the composting rate (over tenfold), and a faster settling of sludge solids and their reuse as a safe, economic and valuable resource.

Radiotherapy of cancer

In continuation of the programme to improve the standard and accuracy in the practice of radiotherapy in developing countries, two new CRPs were brought to the advanced planning stage: a regional CRP on computer assisted planning and dosimetry in the radiotherapy of carcinoma of the cervix in the RCA region and a CRP on computer assisted planning and dosimetry in radiotherapy of head and neck cancers.

A seminar on the organization and training of radiotherapy in Africa included 41 scientific papers, with eight invited lectures on special topics. The sessions covered topics on cancer in Africa, radiotherapy services, radiotherapy techniques, the organization of radiotherapy departments, the status of radiotherapy in Africa, radiotherapy equipment for developing countries and the future of radiotherapy in Africa. The proceedings should prove a valuable reference material for many developing countries, particularly in Africa, which are contemplating starting radiotherapy services.

Brachytherapy project

The project on the brachytherapy of cancer of the cervix uteri in Egypt was continued. The project started in 1983 under the auspices of the IAEA and WHO and was funded by the Direzione Generale per la Cooperazione allo Sviluppo of the Italian Ministry of Foreign Affairs. The aim is to facilitate the use, for instance by hands-on training of technical personnel and developing protocols for local conditions, of a simple, low cost and effective manual after-loading technique for the brachytherapy of early carcinoma of the uterine cervix. The technique was considered simple enough to be adapted for use by district hospitals or other similar institutions in developing countries where facilities for early detection, treatment and available manpower or expertise are limited. The project has been very successful and now serves as a model for introduction in other interested developing countries. The project terminated at the end of 1989.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1984	Radiation sterilization practices significant to local medical supplies and conditions in Africa and the Middle East region	1990	7
1984	Use of chromosomal aberration analysis in radiation protection (jointly with NENS)	1990	14
1985	Radiation sterilization practices for tissue grafts in clinical use for the Asia and the Pacific region (RCA)	1990	10
1985	Radiation treatment of sewage sludge for safe reutilization (jointly with RIPC)	1990	7
1986	Nuclear techniques in the improvement of traditional fermentation practice in developing countries with particular emphasis on cassava (jointly with RIFA)	1989	13

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on radiotherapy for medical physicists in the RCA region	Pakistan	15	2 weeks

Publications

Series and No.	Title
IAEA-TECDOC-493	Improvement of cancer therapy by the combination of conventional radiation and chemical or physical means

Dosimetry

SSDLs

Assistance to improve the performance of Secondary Standard Dosimetry Laboratories (SSDLs) continued. The activity of the SSDLs was analysed on the basis of the SSDL annual reports from 1985 to 1988. A significant increase was found in the number of calibrations performed. The results of the biannual intercomparison service showed an improvement in the accuracy of the secondary standard dosimeters used by the SSDLs.

Dose intercomparison and assurance

In connection with the programme to assist Member States in the improvement of the accuracy in radiotherapy, the IAEA/WHO thermoluminescent dosimetry (TLD) service has been continued. The results of 20 years were analysed. The total number of results were 1984 from 686 radiotherapy centres, mainly from developing countries. The dosimetry at most of the radiotherapy centres investigated was rather unsatisfactory; however, there was a significant improvement for those centres which participated several times.

Development of dosimetry techniques

In an attempt to improve dosimetry in radiotherapy, testing started on the recently developed human shaped phantom. Development of a dosimetry system for electron radiation processing is in progress. The system will be introduced in the International Dose Assurance Service.

Dosimetry laboratory at Seibersdorf

The Dosimetry Unit of the Agency's Laboratory at Seibersdorf, as the Central Laboratory of the IAEA/WHO network of SSDLs, successfully coped with increased service requests for routine dose intercomparisons for hospitals and SSDLs worldwide, calibration of secondary standard dosimeters/field instruments, reference irradiations, development of intercomparison methodologies and training of fellows and scientific visitors.

IAEA network of SSDLs

	1985	1986	1987	1988
Membership				
Member States	44	46	48	49
SSDLs	49	59	61	62
Annual reports provided	34	43	46	51
Staff				
Physicists	71	83	104	116
Technicians	66	71	91	110
Calibrations				
Therapy level	352	560	675	852
Protection level	3 075*	5 104*	5 583*	84 438**
Personnel dosimetry service				
Film	389 805	288 424	713 088	628 957
TLD	643 731	696 276	943 745	807 692

* Calibration of radiation monitors only.

** Calibration of personnel dosimeters also included.

Biennial TLD intercomparison service for SSDLs

	1980/1981	1982/1983	1984/1985	1987/1988
Number of participants	22	20	23	35
Number of results with deviation >3.5%	3	0	4	3

IAEA/WHO TLD service for radiotherapy centres

	1986	1987	1988*	1989
Number of participants				
Dosimeters distributed	150	180		300
Dosimeters returned	93	128		158
Number of results with deviation >5%	29	28		61

* In 1988, dosimeters were not distributed because of a personnel vacancy at WHO.

International Dose Assurance Service (IDAS) for quality control in radiation processing

	1985	1986	1987	1988	1989
IDAS parties					
Member States	13	19	19	19	22
Facilities	14	27	27	27	30
Number of dose checks	40	83	82	73	70

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Development of quality control dosimetry techniques for particle beam radiation processing	1993	10
1988	Testing of the code of practice for absorbed dose determination in photon and electron beams	1990	9
1989	Performance testing of dosimetry equipment	1991	8

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional training course on radiation dosimetry	China	24	4 weeks
Regional seminar for Latin America on calibration procedures in SSDLs together with ARCAL training course on clinical and radiation protection dosimetry	Brazil	17	3 weeks

Publications

Series and No.	Title
Newsletter No. 28	SSDL Newsletter

Nutritional and health related environmental studies

Nutrition

Nuclear and isotopic techniques have continued to play an important role in human nutrition studies. Results from the CRP on human daily dietary intakes of nutritionally important trace elements as measured by nuclear and other techniques were presented at the first WHO/FAO/IAEA Expert Consultation on Trace Elements in Human Nutrition, held in October. This CRP is the first international comparative dietary study of its kind ever carried out using validated analytical techniques; its findings are already playing an important role in reassessing the values to be assigned by WHO and FAO as recommended dietary intakes of minor and trace elements. This programme is also strongly supported by the Agency's Seibersdorf Laboratory, which is responsible for preparing and distributing the samples, and is reporting analytical results for 17 of the elements of interest. Improvements in sample pretreatment have been achieved by the development of a simple and cheap food blender with the critical working parts made of titanium.

For the quality assessment of measurements with stable isotope tracers (deuterium, ^{13}C, ^{15}N and ^{18}O), an intercomparison study based on results submitted by 39 institutes in 20 Member States was completed. Applications of these isotope tracers in human nutrition research continue to grow, and are completely without radiation hazard to the subjects studied.

Environment: non-radioactive inorganic pollutants

Nuclear and isotopic techniques have continued to play an important role in the study of non-radioactive inorganic pollution (e.g. toxic heavy metals). Two major meetings were held (a symposium in collaboration with the National Institute of Standards and Technology, USA, and a regional seminar, held in Indonesia). Reference analytical methods have been developed on sampling and analytical methodologies for instrumental neutron activation analysis of airborne particulate matter, and leaching studies on coal fly ash and other solid wastes with special reference to the use of radioanalytical techniques.

The Agency's Seibersdorf Laboratory provided analytical support for these programmes by making analytical measurements and improving some of the analytical methods. The Laboratory has also been providing similar support for the WMO Background Air Pollution Monitoring Network (BAPMoN). The main role of the Laboratory in BAPMoN during 1989 was to act as a sample collection, data acquisition and distribution centre. In addition, assistance has been provided on sampling procedures and sample storage conditions, as well as on the development of analytical techniques for the WMO Handbook.

Environment: fallout radioactivity

The programme on monitoring of accidentally released radionuclides in environmental and food samples, which was initiated by the Agency in 1986 in response to the Chernobyl accident, has continued. Support was provided for 17 technical co-operation projects and 2 advisory missions. A CRP on rapid instrumental and separation methods for the monitoring of radionuclides in food and environmental samples has been initiated, and supporting work on method development has been carried out in the Agency's Laboratory. Two analytical reference materials have been certified.

Quality assurance

The Marine Environmental Studies Laboratory (MESL) of ILMR organized worldwide intercalibration exercises for trace metals and chlorinated hydrocarbons (pesticides and PCBs) with the participation of 143 laboratories from 57 Member States. Additionally, MESL staff participated in 12 missions (in association with UNEP) in order to provide assistance for setting up quality control programmes in laboratories monitoring marine contaminants. As part of these missions, staff members participated in joint monitoring activities in order to advise the Member State laboratories on the most appropriate sampling procedures. MESL staff also organized a smaller intercalibration exercise and workshop on the analysis of methyl-mercury.

Quality assurance missions were made to Bahrain, Egypt (2), Kuwait, the Libyan Arab Jamahiriya, Morocco (2), Oman, Saudi Arabia and the United Arab Emirates.

Reference methods

As part of an ongoing co-operative programme with UNEP, MESL has continued to co-ordinate the development, testing and revision of reference methods and guidelines for marine pollution measurements. This work involves the co-operation of IOC (the Intergovernmental Oceanographic Commission of UNESCO), WHO, WMO and FAO. New methods were developed at MESL for the analysis of methyl-mercury, tributyl tin (a major pollutant from marine antifouling paints) and selected organophosphorus pesticides. The Reference Method Catalogue currently contains 84 techniques published or in preparation. The methods are being used in international marine pollutant monitoring programmes throughout the world.

Training

Individual and group training courses were organized in MESL for the analysis of pesticides (and PCBs), petroleum hydrocarbons and organotin in marine environmental samples. A total of 12 trainees were received from Algeria, Egypt, Malta, Mexico, Morocco, Spain and Syria. MESL staff provided additional field training during the quality assurance missions described previously.

Instrument maintenance

The MESL maintenance engineer continued to install and service the analytical instruments employed by laboratories participating in UNEP's Mediterranean Action Plan marine pollution monitoring programme (MEDPOL). During 1989 he visited 15 laboratories in 7 countries (Algeria, Egypt, the Libyan Arab Jamahiriya, Malta, Morocco, Tunisia and Yugoslavia) and also provided technical advice to various laboratories in West and Central Africa.

Assistance to Member States

A major new project was initiated to investigate the transport, fate and effects of agrochemicals in a tropical coastal lagoon system in Mexico. The work envisages the use of radiolabelled pesticides in micro and meso-cosm experiments and is being conducted in co-operation with the National University of Mexico and the CEC. The results of the study will be applicable to other Member States in Central America; the extent of the problems they are facing from pesticide contamination was revealed during preliminary surveys by MESL staff. ILMR continued to work with other agencies to develop and improve regional monitoring programmes to assist Member States (Colombia, Costa Rica, Jamaica, Kuwait, Mauritius, Mexico, Nicaragua, Panama) to assess marine pollution and to provide the necessary technical support for their implementation.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1984	Human daily dietary intakes of nutritionally important trace elements as measured by nuclear and other techniques	1990	14
1985	Nuclear techniques for toxic elements in foodstuffs (RCA)	1990	11
1987	Use of nuclear and nuclear related techniques in the study of environmental pollution associated with solid wastes	1992	22
1988	Applications of stable tracers in human nutrition research	1992	15
1988	Rapid instrumental and separation methods for monitoring radionuclides in food and environmental samples	1992	12

Training courses and seminars held

Course/workshop name	Location	No. of participants	Duration
Sampling, sample preparation and data evaluation for multi-element and radionuclide analysis by nuclear and instrumental methods	Germany, Fed. Rep. of	26	4 weeks
Determination of radionuclides in food and environmental samples	Brazil	18	4 weeks
Gamma spectrometry and whole body counting	Iraq	14	2 weeks
Environmental sampling and measurements of radioactivity for monitoring purposes	India	14	1 week

Publications

Series and No.	Title
Technical Reports Series No. 295	Measurement of radionuclides in food and the environment

Industry and earth sciences

Industrial applications

General

Many beneficial applications of radiation and radioisotopes are now well established in industry in advanced countries. The main areas of application include radiation and radiotracer techniques, nucleonic control systems, and non-destructive testing (NDT). In addition, there is growing interest in advanced materials development. The Agency's activities have focused on the assessment of the status of these applications in order to provide a forum for the exchange of information and to help transfer these technologies to developing Member States.

Environmental applications

In connection with the programme on the environmental applications of radiation technology, a CRP on electron beam purification of flue gases was initiated with the participation of research groups from eight countries. Radiation technology for the processing of flue gases is particularly applicable to high sulphur coal and oil burning plants. It is the only technology that removes both sulphur and nitrous oxides in one single step, a dry process, converting pollutants into a marketable agricultural fertilizer. Promotion of the technology and the dissemination of information were carried out at interregional workshops (Poland) and through national seminars for executive management (India, Republic of Korea, Thailand). The transfer of technology is supported by technical assistance projects (interregional, Mexico, Poland).

Biomedical applications and bioengineering

Two CRPs were continued. The programme includes immobilization of bioactive materials, synthesis of biocompatible materials and the development of diagnostic reagents for communicable diseases. Under these programmes, new applications of radiation technology have been developed for producing vascular grafts with improved biocompatibility, materials for soft contact lenses, immobilized monoclonal antibodies for diagnostic purposes, ocular insert devices, wound and burn dressing materials and immobilized drugs for controlled drug delivery systems (hormone therapy and immunotherapy).

Transfer of technology

The identification of industrial opportunities, feasibility studies and training were identified as important areas in which the Agency can significantly contribute. In particular, the effectiveness of the regional co-operative programmes in the promotion and transfer of technology was noted.

Radiation chemistry and technology

An Advisory Group meeting on new developments and trends in radiation chemistry and technology (in Japan) reviewed the latest achievements, including different biomedical applications, environmental applications, manufacture of special property products, electronic components and a number of new applications based on such unconventional radiation sources as high energy X rays, laser beams, intense UV radiation, high energy and heavy ion beams. The recommendations emphasized the importance of developing national capabilities in fundamental and applied radiation research in support of technology transfer and the development of new applications.

Radiotracer technology in industry

Radiotracer applications in the chemical, oil production and refining, steel, cement, automotive and maritime industries have offered considerable economic benefits and have provided solutions to problems which could not be solved by other techniques. An Advisory Group meeting was held to assess the economic benefits of industrial tracer applications. The meeting took note of the fact that tracer technology is well established for trouble shooting, plant optimization, assessment of physical and chemical phenomena, as well as research and development work. It was concluded that there are substantial benefits to be derived in modern industry by the applications of tracer techniques. These benefits arise mainly from savings in material and energy, increase in the productivity and efficiency of plants and technology, improvement of product quality and prevention of accidents by technical diagnostics. The average cost-benefit ratio is about 1:10 in many tracer applications, but remarkable benefits are reported for leak detection in the petroleum industry (1:4500), for gasification optimization (1:50) and in the coal industry (1:20).

Nucleonic control systems

Nucleonic control systems (NCS) and on-stream analysers are now widely used in advanced countries in the coal, mineral, paper and steel industries. The Agency's activities in this area have been aimed at disseminating information on the technical and economic benefits of NCS technology and developing trained manpower.

Non-destructive testing

The transfer of technology is carried out mainly through training courses (national and regional) and by promoting and establishing national schemes and infrastructure for training, qualification and certification of non-destructive testing (NDT) personnel. The Agency's activities are fully harmonized with the new ISO standard on qualification and certification of NDT personnel. The Agency regional projects for Latin America and Asia and the Pacific (RLA and RAS) contribute significantly to the international harmonization of training and certification.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1984	Radiation treatment of sewage sludge for safe reutilization	1990	9
1986	Radiation damage to organic materials in nuclear reactors and radiation environments	1989	8
1988	Radiation processing of combustion flue gases	1992	8
1988	Radiation processing technology applications in bioengineering	1992	9
1988	Development of diagnostic reagents for communicable diseases using radiation processing techniques	1991	6

Training courses and seminars held

Course name	Location	No. of participants	Duration
Industrial radiation sterilization — quality control and sterility assurance (regional, RCA)	Thailand	15	2 weeks
Formulation technology for radiation cross-linking applications (regional, RCA)	China	10	2 weeks
Radiation engineering — electron beam facilities (regional, RCA)	Japan	11	2 weeks
Fourth UNDP/IAEA/RCA meeting on the use of tracer technology in industry	Malaysia	15	3 weeks
Acoustic emission (regional, RLA)	Argentina	16	12 days
Tomography (regional, RLA)	Uruguay	16	5 days
Eddy currents in ferromagnetic materials (regional, RLA)	Chile	16	5 days
Real time radiography (regional, RLA)	Brazil	15	12 days
Vibration monitoring in rotating machinery (regional, RLA)	Mexico	16	12 days
Eddy currents in aircraft maintenance	Uruguay	15	12 days
NDT in quality assurance	Brazil	15	12 days
NDT radiography, level 3 (regional, RAS)	Malaysia	13	19 days
NDT ultrasonics, level 3 (regional)	Philippines	8	19 days

Publications

Series and No.	Title
IAEA-TECDOC-486	Radiation technology for immobilization of bioactive materials
IAEA-TECDOC-527	New trends and developments in radiation chemistry
IAEA Yearbook 1989	Using nucleonic control systems to improve industrial efficiency in Asia

Development of water and mineral resources

Nuclear techniques in ore processing

A report on the technical and economic benefits of nuclear techniques in ore processing (IAEA-TECDOC-520) was published; this discusses the benefits derived from using radioisotopes in on-line analysis gauges in the Australian coal industry and in analysers for on-line mineral processing control, the status and potential of nuclear techniques in ore processing and coal handling in Asia and the Pacific, and the benefits of automatic multielemental analysis of zinc–lead ore slurries by radioisotope X ray fluorescence.

Nuclear borehole logging techniques

Significant progress has been achieved in the CRP on nuclear borehole logging techniques for the determination of rock characteristics. Under this programme, a prototype pulsed neutron porosity logging tool has been constructed and tested; the neutron capture technique has been applied for ash determination in coal seams having a high variation in iron content and a direct uranium logging technique using prompt fission neutrons has been developed. The development and application of small computer systems for the assessment of logging information, the evaluation of a neutron pulse method for measuring thermal diffusion parameters of non-moderating media, and the design and construction of an indigenous neutron capture gamma ray spectral well logging probe have been other significant advances.

Pollutants in coal and coke

Coal is, and is expected to continue to be, a major energy source worldwide; a new CRP has been initiated to develop and evaluate nuclear techniques for the on-line and bulk analysis and evaluation of potential environmental pollutants in coal and coke. The CRP is expected to yield data leading to the more efficient use of coal and coke and minimization of the environmental consequences.

Isotope hydrology

The Agency supported 44 technical co-operation projects in 34 Member States and is also participating in three regional projects in Africa, the Middle East and Latin America.

Groundwater studies

In arid areas, in Africa (Mali, Morocco, Senegal, Zambia, Zimbabwe), Asia (Mongolia), Latin America (Peru) and the Middle East (Jordan, Syria, United Arab Emirates), investigations have led to the identification of aquifers receiving active recharge and aquifers where old groundwater is predominant and virtually no modern recharge occurs. On the basis of the differences in isotopic composition, evidence has been found of recharge from the Nile River and Aswan High Dam Lake in Egypt and of interrelationships between aquifers. Also, the mechanism of salt water encroachment in coastal aquifers has been elucidated (Philippines, Portugal, United Arab Emirates). The study of the Yarada Aquifer in southern Peru has shown that it is recharged by rivers coming from the Altiplano. However, this recharging has probably decreased owing to upstream river water exploitation.

Surface water studies

Artificial tracers have been successfully used to identify dam leakages (Chile, Dominican Republic), to investigate pollutant dispersion in surface water (Chile, Colombia) and to study groundwater recharge (Brazil) and movement (Niger). The results obtained have been incorporated in engineering designs to reduce leakages and pollution and to artificially recharge the groundwater. Environmental isotopes have been used to evaluate a dam site in Albania, and connections between the river and some springs were brought to light. A new site is now being investigated.

Artificial tracers

Sediment gauges have been installed in Colombia, Tunisia and Zaire. These instruments provide information required for dredging operations. Artificial tracers have also been used in the investigation of groundwater flow in the Telona Oasis (Niger).

Isotopic composition of precipitation

A new statistical elaboration of the database on the isotopic composition of precipitation has been undertaken; this has shed new light on regional tritium contamination aspects.

Research contracts

In an effort to develop new techniques and to improve existing methods, the Agency is executing 69 research contracts in 30 Member States. The results obtained so far have helped to solve many complex hydrological problems. In addition to the research contracts, a contract has been signed with the Centro Informazioni Studi Esperienze (CISE), in Milan, Italy, on the use of natural radioactivity in geothermal fluids studies.

Geothermal sources

The exploration of geothermal resources has been supported through a CRP for Latin America, which will terminate in 1990, and a new CRP for Africa, Asia and the Middle East has been initiated. The results so far obtained have identified regions where the geothermal source holds potential for electricity generation.

Co-operation with other United Nations organizations

The Agency continued to co-operate with UNESCO in the field of water resources. A result of this co-operation was the publication by UNESCO of two technical documents in hydrology: "The Use of Environmental Isotope Techniques in Arid Zone Hydrology" and "Single Well and Multiwell Nuclear Tracer Techniques". Co-operation also continued with WMO in collecting and analysing monthly precipitation samples from a global network of stations. The data for the period 1984–1987 have been prepared for publication and will be issued in early 1990.

Atmospheric studies

In co-operation with the Institut für Atmosphärische Radioaktivität (Freiburg, Federal Republic of Germany), weekly air samples were collected. After special treatment, the samples were sent to Freiburg for ^{85}Kr measurements.

Isotopic standards for geochemistry

The Isotope Hydrology Laboratory organized the preparation and shipment of approximately 230 samples from stable isotope reference and intercomparison materials. For an interregional intercomparison test, two water samples with different tritium concentrations were prepared and distributed to 11 laboratories. Two carbonates, Carrara marble and travertine, were procured and prepared for distribution. Together with further materials provided by co-operating institutes, these carbonates will be used for a ^{14}C intercomparison test.

Assistance to other laboratories

Regular contacts exist with laboratories established with the assistance of the Agency. Special efforts were devoted to:

— the installation of a deuterium preparation line in Albania;
— the repair of the inlet system of the mass spectrometer in Colombia;
— the calibration of ^{13}C measurements.

Training

Seven fellows were trained in the Isotope Hydrology Laboratory in the field of isotope measurements and chemical analyses of water samples. A three month group training course was organized and attended by 26 fellows from 18 countries.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1985	Nuclear borehole logging techniques for the determination of rock characteristics	1991	10
1985	Geothermal resources exploration in Latin America (financed by the Government of Italy)	1990	9
1987	Nuclear techniques in the study of pollutant transport in the environment	1992	5

CRPs established in the current year

Subject	No. of years	Participating institutions
Nuclear techniques in the exploration and exploitation of coal: on-line and bulk analysis and evaluation of potential environmental pollutants in coal and coke	3	6
Mathematical models for quantitative evaluation of isotope data hydrology	3	To be awarded in 1990
Application of isotope and geochemical techniques in geothermal exploration in Africa, Asia and the Middle East	3	4

Publications

Series and No.	Title
IAEA-TECDOC-502	Isotope hydrology investigations in Latin America
IAEA-TECDOC-512	Analytical chemistry in semiconductor manufacturing: techniques, role of nuclear methods and need for quality control
IAEA-TECDOC-520	Technical and economic benefits of nuclear techniques in ore processing
Panel Proceedings Series	Isotope techniques in the study of the hydrology of fractured and fissured rocks

Training courses and seminars held

Course name	Location	No. of participants	Duration
Radioisotope techniques in mineral exploitation (regional)	Poland	10	5 weeks
Neutron activation analysis for mineral resources prospecting and materials characterization (regional, RCA)	India	16	3 weeks
Application of nucleonic control systems to coal processing operations	Thailand	6	5 weeks
Application of nuclear analytical techniques for mineral resources (advanced, regional, ARCAL)	Chile	20	4 weeks
Group training in isotope techniques in hydrology	Headquarters	26	3 months
Regional course on the application of isotope techniques in water resources development	Senegal	25	3 weeks
Seminar for Africa, the Middle East, Asia and the Pacific on the application of isotope and geochemical techniques in geothermal exploration	Turkey	42	1 week
Seminar on isotope techniques in hydrology, geochemistry and environmental studies	China	50	2 weeks
Itinerant course: Workshop on isotope techniques in arid zone hydrology	Costa Rica, Venezuela, Uruguay, Peru	119	4 weeks
Workshop on isotope techniques in arid zone hydrology	Syria	15	1 week

Physical and chemical sciences

Nuclear measurements and instrumentation

Computer software

The development of computer software for nuclear applications resulted in 1989 in a final version of a program for quantitative X ray analysis. The software is available free of charge to laboratories in Member States. The development of a set of programs for the conversion of spectra was completed. Work on an advanced software package for neutron activation analysis is in progress.

Multichannel analysis

A workshop was organized to study the properties, advantages and limitations of different types of multichannel analysers, and to compare their suitability for various tasks. A report was prepared.

Instrumentation

To an increasing extent, the Seibersdorf Instrumentation Unit is becoming involved in direct support to the Member States in the field of nuclear instrumentation maintenance. Twenty engineers from 18 developing countries have received intensive training in the laboratories of the Unit, totalling 70 person-months of on-the-job training. The Unit designed and constructed a stack monitor system for on-line measurement of radioactivity in particulates, iodine and noble gases released from research reactors; the prototype model has been put in operation in Greece. The IAEA modular instruments system was improved and a new unit added. The first steps in establishing a nuclear instrumentation network in African countries were completed.

The staff of the Seibersdorf laboratory also offers training in operation, service and maintenance of X ray analytical equipment. Three engineers from Africa were trained in 1989, for 4 months each.

Nuclear and atomic data centre networks

The Agency continued to co-ordinate the activities of worldwide networks of nuclear and atomic data centres and to provide nuclear and atomic data services to Member States. Representatives of national and regional centres were convened to develop new or improved formats and procedures for the compilation and exchange of data. A system for storage and exchange of atomic and molecular data for fusion (ALADDIN) was adopted and successfully introduced into the data management practices of the Atomic and Molecular Data Centre Network (DCN) and fusion application codes. To assure the necessary degree of coherence and co-ordinate the efforts in the further developments of the system, a user network has been established. ALADDIN is currently being extended to incorporate data on plasma–material interactions.

Data services

The Agency fulfilled more than 820 requests from 64 Member States for experimental and evaluated data, data processing computer codes and publications. One of the nuclear data files made available to scientists in Member States was the USSR file of recommended data for the interaction of neutrons with various elements and isotopes for reactor physics calculations and many other applications. This comprehensive data library was tested, documented and disseminated to users together with data processing computer codes.

Support to national data centres

Support in the form of expert advice and computer equipment was given to the national nuclear data centres in China and in Indonesia.

Interregional project on nuclear measurement techniques

A technical evaluation was performed of the results of an interregional project on nuclear measurement techniques which ended in 1989. Under this project, 23 nuclear analytical laboratories from 14 developing countries performed elemental analyses of material samples provided by the Agency's Seibersdorf Laboratory with the most common nuclear analytical techniques introduced by the Agency in developing countries, i.e. X ray fluorescence, fast neutron activation, low level counting and proton induced X ray emission. Comparison of the results of these analyses with the known reference values revealed large discrepancies and inconsistencies, reflecting deficiencies in instrumentation as well as in the proper utilization of the measurement techniques in most of the participating laboratories. As a consequence, intensified training of scientists and technicians in nuclear instrumentation and measurement techniques is planned, with an emphasis on nuclear analytical laboratories in the Africa region and on X ray fluorescence and neutron activation analysis techniques.

Support for nuclear analytical facilities in Africa

In addition to this interregional project, ten nuclear laboratories in individual developing countries, mostly African, were given continued support for the development of nuclear analytical facilities in terms of equipment, expert assistance and manpower training.

Nuclear data applications

Expert groups were convened to review the status of and assess the requirements for atomic and molecular data in fusion plasma research and in the estimation of radiation damage in reactor materials and related safety aspects, and for transactinium isotope decay data required for the estimation of the radiation hazards of radioactive waste. Consultants reviewed recent developments and the requirements for further research regarding nuclear cross-sections for the generation of long lived radionuclides, as well as the compilation and evaluation of fission product yields. A continuing effort was devoted to the development of nuclear and atomic databases to be used in the design of fusion reactors.

X ray and gamma ray standards

A CRP on X ray and gamma ray standards for detector efficiency calibration was completed. Participants from radionuclide metrology institutes of eight countries and two international organizations performed experiments and theoretical data analysis and agreed upon a common set of radionuclides and their radiation characteristics. This information will be published in the Technical Reports Series and recommended as the international reference standard for the calibration of semiconductor detectors used in various fields of applied radionuclide metrology.

Nuclear model parameter measurement and analysis

Also completed was a CRP in which participants measured the emitted neutron angle–energy distributions resulting from the bombardment of 18 different target nuclides with 5–13 MeV protons and 9–13 MeV alpha particles. A consistent set of nuclear level density parameters was obtained for 15 of the 18 nuclides and these results will appear in a forthcoming INDC report. These improved parameters should improve the reliability of current nuclear model programs, which are especially useful in estimating specific nuclear data that, for practical reasons, cannot be measured directly.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1986	Nuclear data needed for neutron therapy	1991	9
1986	Methods of calculation of fast neutron nuclear data for structural materials	1990	16
1987	Double differential neutron emission measurement and analysis	1992	6
1989	Atomic and molecular data needed in radiotherapy	1993	14

CRPs established in the current year

Subject	No. of years	Participating institutions
Atomic and molecular data for fusion plasma edge studies	5	11
Activation cross-sections for the generation of long lived radionuclides	5	6

Training courses and seminars held

Course name	Location	No. of participants	Duration
Advanced interregional course on nuclear electronics	USA	20	12 weeks
Advanced interregional course on interfacing in nuclear experiments	Thailand	20	8 weeks
Regional course on advanced aspects of nuclear spectroscopy	Paraguay	13	3 weeks
Regional course on maintenance of radiation protection equipment	Colombia	13	3 weeks
Regional course on the design and production of printed circuit boards	Cuba	11	3 weeks
Regional course on nuclear instrumentation maintenance	Zambia	25	6 weeks
National course on nuclear instrumentation maintenance	Jordan	23	6 weeks
Interregional course on nuclear measurements and methods in reactor and personnel dosimetry	USSR	20	3 weeks
Neutron generators	USSR	15	5 weeks

Publications

Series and No.	Title
IAEA-TECDOC-491	Nuclear data for the calculation of thermal reactor reactivity coefficients
IAEA-TECDOC-506	Atomic and molecular data for radiotherapy
IAEA-TECDOC-530	Nuclear electronics laboratory manual, 1989 edition
Monograph published by World Scientific	Applied nuclear theory and nuclear model calculations for nuclear technology applications
INDC(NDS)-212/G	Final report on the REAL-84 reactor dosimetry exercise
INDC(NDS)-214/LJ	Status review of methods for the calculation of fast neutron nuclear data for structural materials of fast and fusion reactors
INDC(NDS)-220/L	Physics of neutron emission in fission: proceedings of a consultants meeting
INDC(NDS)-223/GF	Fusion evaluated nuclear data library (FENDL): proceedings of an IAEA specialists meeting
INDC(NDS)-225/MS	IAEA specialists meeting on the required database for beam penetration in large tokamaks: summary report
INDC(NDS)-226/MA	IAEA Advisory Group meeting on particle-surface interaction data for fusion: summary report
IAEA-NDS reports	Description of various computerized data files available from Nuclear Data Section
INDC country coded reports	Technical reports on nuclear data related research in Member States

International Centre for Theoretical Physics

(Jointly operated by the IAEA and UNESCO)

Twenty-fifth anniversary

The Centre celebrated its 25th anniversary on 31 October 1989 with a ceremony at which the Prime Minister of Italy, Mr. Giulio Andreotti, was the guest of honour, followed by a symposium entitled "Frontiers in physics, high technology and mathematics", attended by 138 participants.

Fields of research and training

The main fields of research and training for research at the Centre in 1989 were: fundamental physics (high energy and particle physics, cosmology and astrophysics); condensed matter, atomic and molecular physics (condensed matter and related, atomic and molecular physics, materials science); mathematics (applicable mathematics, analysis, differential geometry, ergodic theory, theoretical fluid mechanics); physics and energy (nuclear physics, plasma physics, non-conventional energy); physics and the environment (soil physics, environmental radioactivity, physics of the atmosphere); physics of the space (microgravity); applied physics and high technology (microprocessors, communications, lasers, computational physics, telematics, remote sensing, instrumentation); and science, high technology and development.

Some 4100 scientists took part in the activities of the Centre and in the Programme for training at Italian laboratories, staying for a total of almost 4800 person-months. Sixty-two per cent of them were from developing countries, accounting for 84% of the total person-months. Associate Members from developing countries numbered 190, and 652 of them were researchers from federated institutes in developing countries.

Fundamental physics

Course name	Total No. of participants	Participants from developing countries	Duration
School and workshop on superstrings	198	61	Two weeks
Summer school in high energy physics and cosmology	246	155	June–August
Recent developments in conformal field theories	100	26	July
Supermembranes and physics in 2+1 dimensions			October

Mathematics

Course name	Total No. of participants	Participants from developing countries	Duration
Workshop on theoretical fluid mechanics	85	62	3 weeks
Topical meeting on hyperbolic geometry and ergodic theory	177	100	April
Topical meeting on variational problems in analysis	180	110	November
College on differential geometry			

Condensed matter, atomic and molecular physics

Course name	Total No. of participants	Participants from developing countries	Duration
Fourth international workshop on computational condensed matter physics on total energy and force methods	118	20	4 days
College on atomic and molecular physics (photon assisted collisions in atoms and molecules)	86	62	3 weeks
Experimental workshop on high temperature superconductors	96	77	2 weeks
Conference on oxygen disorder effects in high T_c superconductors	75	47	April
Working party on modelling thermomechanical behaviour of materials Working party on fracture physics	69	52	2 weeks
Spring college on materials science (ceramics and composite materials)	138	110	April-May
Research workshop on condensed matter, atomic and molecular physics Workshop on strongly correlated electron systems Symposium on condensed matter physics Working party on condensed matter properties of neutron stars	438	303	June-September

Physics and energy*

Course name	Total No. of participants	Participants from developing countries	Duration
Workshop on perspectives in nuclear physics at intermediate energies	124	33	5 days
College on plasma physics	172	106	4 weeks
Workshop on materials science and physics of non-conventional energy sources Workshop on the interaction between physics and architecture in environment conscious designs	251	192	3 weeks

* Some research was also carried out during the year in plasma physics by 11 physicists from developing countries.

Physics and the environment

Course name	Total No. of participants	Participants from developing countries	Duration
Workshop on radon monitoring in radioprotection, environmental radioactivity and earth sciences	97	63	2 weeks
College on soil physics			3 weeks
Workshop on atmospheric radiation and cloud physics	179	126	3 weeks

Applied physics and high technology

Course name	Total No. of participants	Participants from developing countries	Duration
College on microprocessors	114	110	3 weeks
Telematics	92	85	4 weeks
ICTP–INFN course in basic VLSI design techniques	47	36	4 weeks
Basic telecommunications science Theoretical and experimental radiopropagation physics	173	143	6 weeks
Remote sensing techniques with applications to agriculture, water and weather resources	101	76	
ICFA school on instrumentation in elementary particle physics	102	40	2 weeks

Space physics

Course name	Total No. of participants	Participants from developing countries	Duration
Workshop on materials in microgravity	73	32	

Applied physics and high technology

The High Temperature Superconductivity Laboratory hosted 12 scientists from developing countries in the spring out of a total of 16. Fifteen physicists from developing countries, out of 16 attending, have worked in the Microprocessors Laboratory.

Anniversary Adriatico Research Conferences

In 1989, the Anniversary Adriatico Research Conferences series included short meetings on: the interface between quantum field theory and condensed matter physics; quasicrystals; strongly correlated electron systems; and computations in physics and physics in computation. One hundred and thirty-eight scientists from developing countries, out of a total of 305, took part.

Training at Italian laboratories

One hundred and seventy scientists from developing countries carried out research at Italian academic and industrial laboratories under a programme which started in 1982 with the financial support of the Italian Direzione Generale per la Cooperazione allo Sviluppo (Ministry for Foreign Affairs, Rome, Italy).

External activities

In the field of training for physics and mathematics teachers, the Centre sponsored 133 courses, workshops and symposia in 38 countries. Ten fellowships for visiting scholars to eight countries were granted. These programmes were financed by the Italian Direzione Generale per la Cooperazione allo Sviluppo (Ministry of Foreign Affairs, Rome, Italy).

Meetings hosted by the Centre

The Centre hosted 19 meetings. Nine of them were organized by the Third World Academy of Sciences. Other organizing institutions were the Italian National Institute of Nuclear Physics, the International Centre for Genetic Engineering and Biotechnology, the International School for Advanced Studies and the Trieste Research Area.

Books and equipment donation programme

During 1989, the Centre was able to distribute 13 184 journals, 4062 proceedings, 6119 books and 8289 publications to more than 700 institutions in 100 developing countries. Besides the donations directly distributed by the Centre, about 100 donations of complete sets of back-issues of journals have been shipped directly by the donors to about 60 institutions in 40 developing countries.

Equipment from CERN was sent to institutions in the following countries: China, Colombia, Iran, Jordan and Pakistan. The Centre received a generous offer of approximately 43 items of surplus equipment from Dr. Iftikhar Ahmad in London. They were sent to 13 universities in the following countries: Bangladesh, Colombia, Egypt, Iraq, Jamaica, Nigeria, Pakistan, Peru, Tanzania and Uganda.

Awards

Michael B. Green from Queen Mary College, London, UK, and John H. Schwarz from the California Institute of Technology, Pasadena, California, USA, were the recipients of the 1989 Dirac Medals of the Centre "for their basic contributions to the development of superstring theory. Most significant was their discovery that chiral gauge anomalies are absent for a class of ten dimensional superstring theories".

The 1989 ICTP Prize in honour of Hideki Yukawa was awarded to Dr. Ashoke Sen from the Tata Institute of Fundamental Research, Bombay, India "for his contributions to string theory and, in particular, for the application of the sigma model approach to the heterotic string theory".

Reports

In 1989, 432 preprints and internal reports were issued.

Utilization of research reactors and particle accelerators

Ageing of research reactors

In the light of the fact that 70% of the operating research reactors in the world are older than 20 years, a new component has been introduced into the programme: a study of ageing problems. A working group prepared a report which includes a worldwide list of research reactors with observations on their condition. Recommendations were made about the necessary action to be taken in the future to assure continuation of safe operation.

Fuel burnup

A study was conducted as an initial step in the preparation of a guidebook on the different methods for burnup determination of research reactors. The objective is to optimize reactor fuel use, check burnup calculations and improve reactor safety.

Symposium

An international symposium was held in Chalk River, Canada, on research reactor safety, operation and modifications. It was apparent from the papers that safety related issues (licensing and relicensing, safety analysis, PSA studies, accident mitigation and personnel training) are becoming subjects of increasing discussion amongst operators. Ageing was another topic that attracted interest. The proceedings of the meeting provide valuable information on necessary modifications to research reactors to ensure better operation and safety.

Regional project

Initial steps were made in the preparation for a regional project on research reactor utilization in Asia and the Pacific: a programme formulation meeting was held in Malaysia.

Research reactor data

	1975	1980	1985	1987
Number of facilities	371	356	332	329
Total steady thermal power (MW)	4020	4517	3803	3867

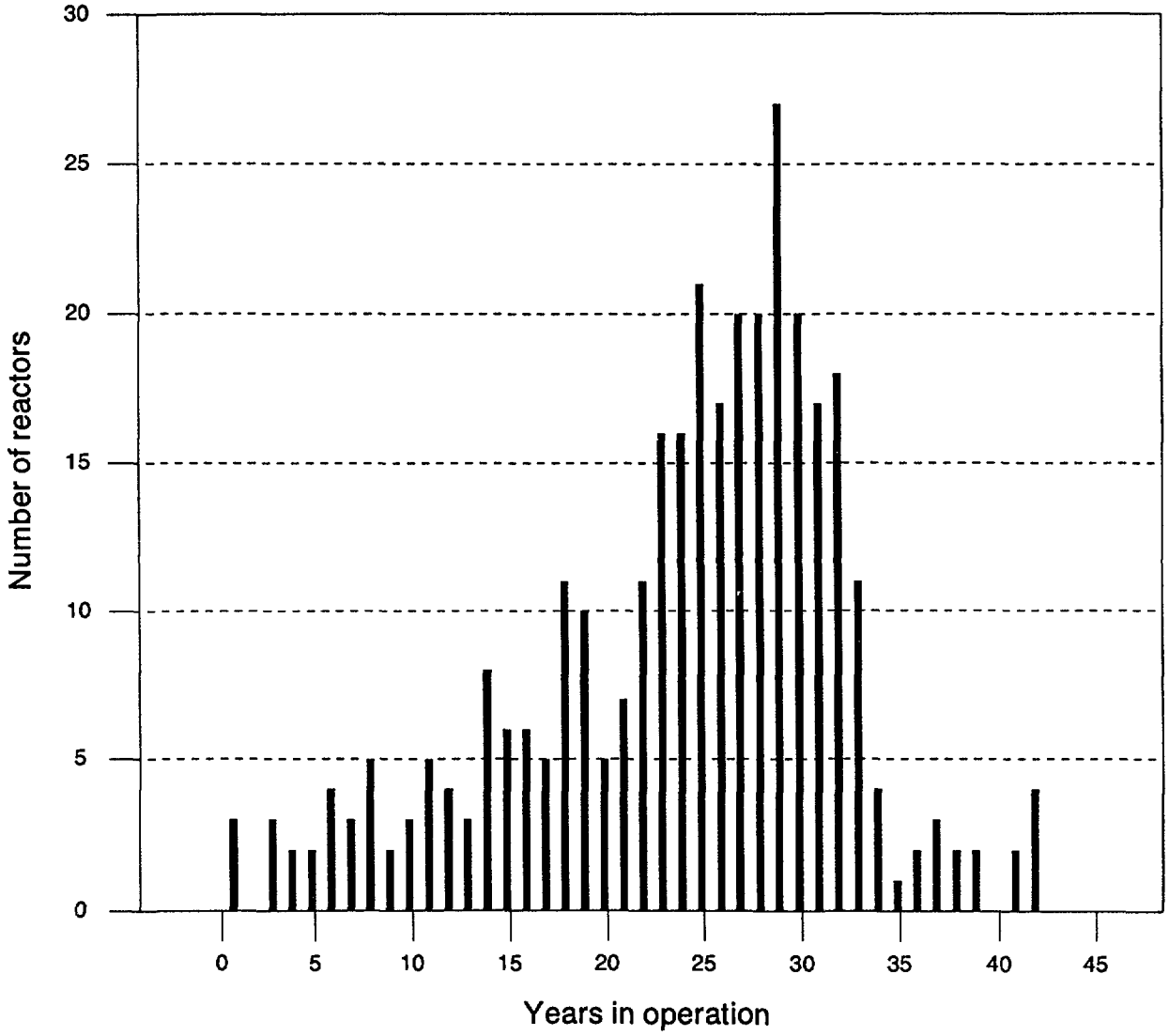
CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Analysis of research reactor cores for use of LEU fuels	1992	6

CRPs established in the current year

Subject	No. of years	Participating institutions
Application of personal computers to enhance operation and management of research reactors	3 years	10 (expected)

AGE DISTRIBUTION OF OPERATING RESEARCH REACTORS



Training courses and seminars held

Course name	Location	No. of participants	Duration
Research reactor operator training	Thailand	18	4 weeks
Advanced course on application of computer codes to reactor calculations (ARCAL V)	Argentina	12	2 weeks
Small computers in research reactor operation and use (ARCAL V)	Mexico	13	2 weeks

Publications

Series and No.	Title
Reference Data Series No. 3	Nuclear research reactors in the world
Technical Directories	Directory of nuclear research reactors

Chemistry

Production of radioisotopes and radiopharmaceuticals

The programme aims at assisting laboratories in developing Member States to strengthen their capability to develop an appropriate infrastructure for the production of radioisotopes with research reactors and cyclotrons as well as radiopharmaceuticals, including quality control techniques and procedures. Several potential hepatobiliary imaging agents were investigated and evaluated in a CRP (1983–1989) and the results published in IAEA-TECDOC-532. Alternative technologies for the preparation of $^{99}Tc^{m}$ generators using low power research reactors were investigated through a CRP which has recently ended (1983–1989). From several possibilities, two technologies are being selected as the most promising for further development and evaluation that will be conducted through a new CRP.

Cyclotron produced radiopharmaceuticals

An Advisory Group meeting discussed the basic criteria for the quality control of cyclotron produced radiopharmaceuticals in nuclear medicine and internationally acceptable guidelines for their implementation. The report, one of the first documents to address this issue, surveys the most advanced techniques and procedures, with particular reference to short lived positron emitting radiopharmaceuticals, and provides guidelines for the organization of regulatory systems.

Fission ^{99}Mo

A publication (IAEA-TECDOC-515) was produced, dealing with the production of ^{99}Mo for the preparation of $^{99}Tc^{m}$ generators for use in nuclear medicine. It makes particular reference to the recent trends in target and process technology development using low enriched uranium (LEU) and its availability and economic implications. With reference to the concern about the proliferation of weapons usable uranium (>90%), the meeting concluded that the amount of plutonium produced in irradiated uranium targets for production of fission product molybdenum is not significant from a proliferation point of view.

Analytical quality control

There is a need for laboratories in developing Member States to increase the level of analytical chemistry, particularly for analysis of matrices of biological and environmental origin at the trace and subtrace levels, and to strengthen their capabilities to provide higher quality nuclear analytical services. A CRP was established under the framework of ARCAL aimed at improving the utilization of nuclear analytical techniques, such as neutron activation analysis, and energy dispersive X ray fluorescence analysis in the determination of trace elements of nutritional as well as toxicological significance in products derived from the agro-industry, including food. A longer term goal is to bring the laboratories of the region to a level at which they reliably provide analytical services to various sectors of the national economy.

Analytical quality control services

The activities of the Chemistry Unit of the Seibersdorf Laboratory are intended to support the Agency's programmes through the provision of analytical quality control services (AQCS) and through training programmes that increase the technical ability of specialists from developing countries in analytical chemistry. The Chemistry Unit also provides support for the Background Air Pollution Monitoring Network (BAPMoN) of WMO, by analysing samples of precipitation and aerosol particles collected by stations all over the world. The samples are analysed for ten constituents, including lead, zinc, cadmium and various anionic pollutants, such as sulphate and nitrate.

Analytical quality control services (cont.)

Each year, the AQCS programme dispatches reference materials and materials for intercomparison runs in response to approximately 1000 orders from Member States and for training courses and CRPs.

During 1988–1989, the AQCS programme organized five intercomparison runs with the first post-Chernobyl materials, and two biological and two marine reference materials with elevated levels of radioactivity from the Chernobyl nuclear plant accident are now available.

Intercomparison runs

In 1989, two intercomparison runs (IAEA-153 milk powder for trace elements, and IAEA-321 milk powder for radionuclides) and an intercomparison re-run (A-14 milk powder for radionuclides and some minerals) were completed by the Seibersdorf Laboratory. The main purpose of the intercomparison re-run was to update the recommended values of A-14 reference material.

Other intercomparisons (IAEA-156 clover for radionuclides and IAEA-312 soil and IAEA-313 and IAEA-314 stream sediment for radium, uranium and thorium) are still running.

Intercomparisons, requests, reference materials (RMs) available and sales income from AQCS activities, 1986–1989

Year	Intercomparisons	Requests	RMs available	Sales income
1986	24	4980	39	$ 58 240
1987	24	5297	38	$ 67 000
1988	33	5649	46	$108 490
1989	27	5400	50	$ 67 000

Radiotracers in preconcentration procedures

To encourage development and innovation of new separation and preconcentration procedures for the analysis of trace elements of interest in environmental control, a new CRP on radiotracers in the development of new separation techniques for trace element analysis by nuclear methods, with special emphasis on environmental research, has been initiated. The results of this CRP are expected to lead to the development of novel separation and preconcentration methods and a widening of the theoretical understanding of these methods.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1983	Development of $^{99}Tc^{m}$ generators using low power research reactors	1989	9
1988	Nuclear analytical techniques for trace element analysis in agroindustrial products and food 1990	1990	11

CRPs established in the current year

Subject	No. of years	Participating institutions
Radiotracers in the development of new separation techniques for trace element analysis by nuclear methods, with special emphasis on environmental research	3	9

Training courses and seminars held

Course name	Location	No. of participants	Duration
Research reactor production of radioisotopes	India	14	3 weeks
Radioisotope production and processing	Mexico	13	4 weeks
Modern aspects in radiopharmacy	Chile	17	4 weeks
Modern aspects in radiopharmacy	Czechoslovakia	16	4 weeks

Publications

Series and No.	Title
IAEA-TECDOC-515	Fission molybdenum for medical use
IAEA-TECDOC-532	Development of new radiopharmaceuticals
Report	Modern aspects of radiopharmaceutical research
Report	Quality control of cyclotron produced radiopharmaceuticals
ARCAL-8903	Nuclear analytical techniques
ARCAL-8908	Nuclear analytical techniques for trace element analysis in agroindustrial products and foods

Radiation protection

Basic principles and criteria

Basic criteria

The Basic Safety Standards (BSS) for Radiation Protection (IAEA Safety Series No. 9, first issued in 1962 and most recently in 1982) are based on the recommendations of the International Commission on Radiological Protection (ICRP). Currently, the ICRP is revising its basic recommendations and is preparing documentation on several subjects for which the Agency supplied input, such as the monitoring of internal contamination, optimization in decision making for radiation protection, and control of probabilistic exposures. The new ICRP recommendations, and especially the changes that may result from the revised risk factors for human radiobiological effects, could have major implications for regulatory systems and regulated industries in Member States, as well as for the Agency's work, particularly the planned revision of the BSS in 1991.

Exposure situations and safety criteria

An important step towards consistency in safety matters is the development of universal safety criteria for the three types of situations involving exposures: planned (normal exposures), potential (probabilistic exposures), and existing (de facto exposures) such as those resulting from naturally occurring radionuclides or from an accident. In practice, the ICRP system of dose limitation (which is included in the BSS) applies only to normal exposures assumed to occur with certainty. The Agency defined criteria for applying radiation safety principles to sources potentially causing exposures (published as IAEA Safety Series No. 104).

For de facto exposures, several events in 1989 added considerable momentum to the goal of an international consensus on protection principles for the public and workers. Technical experts from 16 countries and 8 organizations agreed in December to the adoption of three main principles for guiding decisions on intervention levels applicable to accident situations — justification, optimization and threshold dose limitation to prevent deterministic health effects. The meeting also resulted in a final draft report defining the Agency's policy regarding protection principles for sources not under normal control and their application to public and worker protection following a major accident. The report describes a method for establishing a coherent set of internationally recognized intervention levels. The group also considered criteria for taking measures to protect the public after an accident, and the application of the principles for controlling the consumption of contaminated food. This report, to appear in the IAEA Safety Series, reflects both safety advances and the experience gained internationally since the Agency issued its former guidance (IAEA Safety Series No. 72) in 1985.

Intervention criteria

The numerical dose levels recommended by the USSR authorities as intervention criteria to protect the population of the Soviet Union in the years after the Chernobyl accident are generally considered to be in line with internationally recognized levels. This emerged from discussions at an informal meeting, suggested by the USSR National Committee on Radiological Protection of the Ministry of Health and arranged by the Agency in Vienna, of nearly 100 experts from 20 countries. The meeting dealt mainly with problems arising from long term contamination by radioactive substances after radiation emergencies in general, and the post-Chernobyl situation, in particular. The experts generally

Intervention criteria (cont.)

supported a specified lifetime dose of 350 mSv resulting from the Chernobyl accident for the exposed individuals in the critical groups in the USSR. It was agreed that national authorities should be responsible for deciding the dose criteria for intervention purposes, in line with the relevant approaches of the ICRP and in accordance with the local situation and the severity of the accident.

Guideline exemption levels for radionuclide contamination of food

Guideline exemption levels for the radionuclide contamination of food moving in international trade were adopted at the July session of the Codex Alimentarius Commission, the joint body of the WHO and the FAO responsible for setting international food standards. The proposed levels are based on health and safety criteria and are intended to apply to radionuclide contamination following accidents.

Radiation safety services

Since 1984, the Agency has undertaken Radiation Protection Advisory Team (RAPAT) missions to Member States requesting assistance in reviewing infrastructural needs and in defining a long term strategy for technical assistance and co-operation.

Although RAPAT missions have defined country specific solution paths for the nearly fifty countries visited since the programme began, follow-up has consisted largely of ad hoc technical co-operation tasks, rather than co-ordinated elements of a long term strategy. To overcome these shortcomings, the Agency began an internal review of the policy and procedural changes needed to provide more effective interdepartmental co-ordination and to ensure that adequate radiation protection measures are implemented concurrently with IAEA technical assistance projects in Member States.

Regional co-operation on radiation safety

In line with RAPAT recommendations, regional projects are under way for several Member States. The main objectives of the regional project started in 1989 for countries in the Middle East are the training of national authority employees and the development of legislation and organizational measures. Fourteen countries in the Asia-Pacific region have extended their co-operation to include the strengthening of their radiation protection infrastructures. Cuba and Mexico joined the 12 countries actively co-operating on radiation safety issues as part of ARCAL.

RAPAT missions, 1986–1989

1986 Total visits: 11	1987 Total visits: 8	1988 Total visits: 12	1989 Total visits: 10
Dominican Republic	Colombia	Bangladesh	Cameroon
Ecuador	Jordan	Costa Rica	Cuba
Egypt	Korea, Republic of	Côte d'Ivoire	El Salvador
Iceland	Peru	Ethiopia	Ghana
Kenya	Philippines	Greece	Iran, Islamic Rep. of
Mexico	Sudan	Guatemala	Korea, Democratic People's Republic of
Panama	Syrian Arab Republic	Indonesia	Mongolia
Portugal	United Republic of Tanzania	Jamaica	Morocco
Venezuela		Madagascar	Thailand
Zaire		Nigeria	Zimbabwe
Zambia		Senegal	
		Viet Nam	

Personal monitoring services

Traditionally, the Agency has provided personal monitoring services to its staff, technical co-operation experts on mission and trainees from Member States. The Agency is also responding to the need for these services in its Member States where such services are not locally available. The following table lists the dosimetry services provided by the Agency for the period 1986–1989. In addition, an agreement was reached with WHO that, beginning in 1990, the Agency would provide personal monitoring services to ten countries, some of which are IAEA Member States. The countries are Afghanistan, Bangladesh, Djibouti, Egypt, Kiribati, Nepal, Nigeria, Pakistan, Philippines and Democratic Yemen.

Personal monitoring services provided by the Agency, 1986–1989

	TLD[a] evaluations	Fast neutrons	Extremity dosimeters	Area monitoring	Whole body counting	Urine analysis
1986	8500	90	420	350	1125	430
1987	8500	150	260	400	980	570
1988	9000	380	500	420	1000	800
1989	9700	285	740	510	905	1830

[a] TLD: thermoluminescent dosimetry.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Radiation and nuclear safety	Argentina	12	8 months

Publications

Series and No.	Title
IAEA/HPRA/14	Health physics research abstracts No. 14
Proceedings Series	Radiation protection in nuclear energy, Vol. 2

Occupational radiation protection

Trade union interest in nuclear safety

Representatives of trade unions met at IAEA Headquarters in April to discuss their interest in promoting international co-operation for the enhanced safety of all civilian nuclear facilities. The main proposals summarized by the chairman of this meeting are contained in a report which the Agency submitted to the General Conference (GOV/INF/567). While union representatives believe that the prime responsibility for developing an effective nuclear safety regime must lie with the utilities operating nuclear facilities and with the relevant state authorities, they stressed the need for independent scrutiny at the international level of national safety efforts and made several proposals to the Agency for international action. The Agency has recommended that Member States consider the ideas and proposals advanced.

Mining and milling of radioactive ores

The latest result of Agency co-operation with the ILO and WHO in the development and provision of guidance on radiation protection in the mining and milling of radioactive ores is IAEA Safety Series No. 95, on the organization of radiation protection in the mining and milling of radioactive ores and on monitoring requirements, including methods, instrumentation, and medical surveillance. It reflects the major technological advances that have occurred in this area since the Agency issued its former guidance (IAEA Safety Series No. 43) in 1976.

Publications

Series and No.	Title
Safety Series No. 95	Radiation monitoring in the mining and milling of radioactive ores

Environmental assessment and protection

Applying principles for environmental protection

Two publications issued in the IAEA Safety Series provide assistance in applying principles for limiting the environmental release of radioactive effluents. In Safety Series No. 92, a conceptual framework is outlined for establishing upper bounds to individual doses from global and regional sources. In Safety Series No. 90, the Agency provides guidance on the setting of limits for the release of radioactive substances during normal operations in the mining and milling of radioactive ores, and on assessing the resulting individual and collective doses.

Model evaluation and validation

Two Agency sponsored CRPs are addressing the problems of the uncertainty and reliability of model predictions. Both programmes stem from recommendations by INSAG following the Chernobyl accident and the adoption of the international Convention on Early Notification of a Nuclear Accident. The research conducted under the ATMES (Atmospheric Transport Model Evaluation Study) programme aims to validate long range transport models for atmospheric pollutants. Participants are using the recently completed quality assured database for their comparisons of model predictions and the measured data. Co-sponsors are WMO and the CEC.

The second programme, known as VAMP (Validation of Models for the Transfer of Radionuclides in Terrestrial, Urban, and Aquatic Environments), represents a collaborative endeavour by the IAEA Divisions of Nuclear Safety and Nuclear Fuel Cycle and Waste Management, and the CEC. At meetings in December, members of the four working groups reported success in defining model parameters and formulating scenarios for model validation exercises in 1990.

Developing an environmental database

Progress has been made in overcoming the various difficulties involved in developing a database for radioactivity measurements in environmental materials, such as the need to accommodate many types of environmental samples, the wide variety of formats used to transmit data and the lack of a system of quality assurance of the data. For example, the geographical co-ordinates for the sample locations in 17 countries have been loaded into the database. Currently, about 60 000 records of data for about 150 different types of environmental samples compiled can be accessed from the IAEA mainframe computer. Work also began on re-evaluating the existing mainframe database system and on exploring methods of facilitating the use of the system through the transfer of the database to commonly available PC software.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Atmospheric transport model evaluation study (ATMES)	1991	1
1988	Radon in the human environment	1993	0[a]

[a] Proposals have been received and are being processed.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Radioactivity measurements for environmental monitoring purposes	France	22	5 weeks

Publications

Series and No.	Title
Safety Series No. 90	The application of the principles for limiting releases of radioactive effluents in the case of the mining and milling of radioactive ores
Safety Series No. 92	Principles for the establishment of upper bounds to doses to individuals from global and regional sources

Safe transport of radioactive materials

Safety Series No. 6

As part of the review process for the 1991 supplement to IAEA Safety Series No. 6, Supplement 1988, work centred on preparing provisions for the transport of uranium hexafluoride and on formulating stringent safety requirements for the air transport of plutonium. The Agency is guided in this work by its Standing Advisory Group on the Safe Transport of Radioactive Material (SAGSTRAM), which met in April.

Each year, several tens of millions of consignments of radioactive materials are transported safely around the world. A major factor is the widespread use of the Regulations for the Safe Transport of Radioactive Materials, which were first issued by the Agency in 1962 and are continuously updated to embody changes in transport conditions and safety advances; the latest update appeared in December 1988 (Safety Series No. 6, Supplement 1988).

Database development

To assist those implementing transport regulations, the Agency has five databases (PACKTRAM, EVTRAM, SHIPTRAM, REDTRAM, EXTRAM) at various stages of development.

Work started in 1989 on SHIPTRAM (to record information on shipments in the nuclear fuel cycle), on REDTRAM (to record information on research in progress and a relevant bibliography) and on EXTRAM (to record occupational exposures associated with the transport of radioactive material).

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Radiation protection implications of transport accidents involving radioactive materials	1990	6
1988	Development of probabilistic safety assessment techniques related to the safe transport of radioactive material	1991	12

Publications

Series and No.	Title
IAEA-NCAL-20	National competent authorities list No. 20
Safety Series No. 6	Regulations for the safe transport of radioactive material, 1985 edition — Supplement 1988

Emergency planning and preparedness

Experience in recovery operations

Worldwide experience from recovery operations following a major nuclear accident or a radiological emergency was at the core of discussions by some 250 experts participating at an Agency symposium in November. The accidents at Three Mile Island and at Chernobyl served as starting points for reviewing the lessons learned about recovery operations. Other reports included recovery operations conducted after the emergencies in Brazil, Mexico and El Salvador. A special session was devoted to reports by Soviet specialists on their experience in mitigating the radiological and radioecological consequences of the accidental releases of radioactive materials in Kyshtym (Southern Urals) in 1957. The proceedings of the symposium are in publication.

Guidance on emergency response

Four documents were issued in the IAEA Safety Series (Nos 91, 94, 97 and 98), dealing specifically with enhancing Member States' response capabilities.

Accident notification and emergency assistance

To meet its obligations under the conventions on the early notification of a nuclear accident and on emergency assistance, the Agency has set up a 24-hour Emergency Response System (ERS). The system was formally put into operation on 18 January 1989, though it has been in interim operation since March 1988. The ERS can respond rapidly and authoritatively to emergencies by informing national authorities about accidents and by co-ordinating assistance that Member States, the Agency and other international organizations could provide. Communication can be by telephone, telex or telefax, as well as through the Global Telecommunication System (GTS) of WMO, which can simultaneously transmit voluminous data to many countries. The Emergency Notification and Assistance Technical Operations Manual (ENATOM) and the supplementary manual on the use of the GTS have been distributed to Member States.

In February, El Salvador requested technical assistance in handling an occupational accident involving the overexposure of workers. Although the Government is not a signatory to the convention, the Agency provided assistance, co-ordinated through the ERS. During the planning for the possible atmospheric re-entry of the satellite COSMOS 1900, the Government of the USSR had notified the Agency that it would invoke the notification convention if needed.

Publications

Series and No.	Title
Safety Series No. 91	Emergency planning and preparedness for accidents involving radioactive materials used in medicine, industry, research and teaching
Safety Series No. 94	Response to a radioactive materials release having a transboundary impact
Safety Series No. 97	Principles and techniques for post-accident assessment and recovery in a contaminated environment of a nuclear facility
Safety Series No. 98	On-site habitability in the event of an accident at a nuclear facility

Control of radiation sources

Safe handling of sealed and unsealed radiation sources

The Agency has strengthened its activities in the use and control of radiation sources, with emphasis on the development and provision of guidance. To broaden the base of expertise, two interregional training courses were sponsored on the safe handling of sealed and unsealed sources of radioactive material, in Argonne, Illinois, USA, and Dublin, Ireland, respectively.

Occupational accident

Radiation processing has maintained a good safety record, marred by only a few serious accidents leading to human deaths over the last 40 years, the latest occurring in February at an industrial irradiation facility for sterilizing packaged medical products in El Salvador. Following a request by the Government of El Salvador for emergency assistance, the Agency arranged for a team of specialists from the the Radiation Emergency Assistance Center in Oak Ridge, Tennessee, USA, to assist in the diagnosis and treatment of the overexposed individuals. An Agency specialist in the medical treatment of overexposed individuals also provided assistance.

Post-accident review

A post-accident international review was undertaken to document the facts of the occupational accident and to define lessons for those with safety responsibilities for such facilities. In related work, an Agency report providing international guidance on the safe design, licensing and operation of gamma and electron irradiation facilities was completed for publication.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Safety and regulation of sealed sources of radioactive material	USA	12	8 months
Safety and regulation of unsealed sources of radioactive material	Ireland	24	4 weeks

Exposure assessment and handling

ICRU co-operation

The Agency enhanced its co-operation with the ICRU, the sister body of the ICRP. It has helped to facilitate the practical application of the new ICRU quantities for determining dose equivalents from area and personal monitoring to external monitoring systems through direct contact with radiation protection programmes in its Member States and serves as a vehicle for the international harmonization of dosimetry systems.

Intercomparisons of individual monitoring

The Agency's ongoing CRP for international intercomparisons of individual monitoring has given specialists from the 19 participating laboratories an opportunity to develop a consistent framework for interpreting the dosimetry measurements obtained under different laboratory conditions. The first phase of this programme, completed in 1989, resulted in major conclusions with regard to phantom selection for calibration. The ICRU has used these to significantly modify its draft report on determining dose equivalents from external radiation sources.

Monitoring for internal contamination

In following up the implementation of new ICRP recommendations for assessing the intake of radioactive materials from bioassay measurements, the Agency convened a technical meeting in November to consider advances made in the development and use of basic methods for direct measurement of incorporated radionuclides in individuals.

A Technical Committee meeting in January resulted in a final report providing guidance for authorities charged with designing and rapidly implementing a scheme for internally monitoring large groups of exposed people (to be published in the IAEA Safety Series).

The protection measures recommended by both the ICRP and the Agency for workers are based on characteristics for an average Caucasian male in his twenties, with a west European/North American type of diet. To help provide a more universal base for dose assessment, the Agency is co-ordinating an international CRP on the compilation of anatomical, physiological and metabolic characteristics for a reference Asian man. The programme is funded through the contribution of the Government of Japan to the RCA.

Dose per unit intake factors for the public

A complementary activity is the CRP on dose per unit intake factors for the public. Customarily, annual limits of intake of radionuclides for members of the public have been set by using a fraction of that received by the worker. Thus, implicitly, the dose per unit intake for members of the public is considered to be comparable to that for workers. The Agency is collaborating with the ICRP, which has made considerable progress towards determining the dose per unit intake factors for specific radionuclides by different members of the public. The main focus of the Agency's efforts is on the biokinetics of radionuclides in the aftermath of radiation accidents and on information gathering for areas other than western Europe.

Publications

Series and No.	Title
IAEA-TECDOC-516	*Medical aspects of the Chernobyl accident*

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1982	Use of chromosomal aberration analysis in radiation protection	1990	14
1988	Dose per unit intake factors for the public	1991	2
1988	Intercomparison programme for individual monitoring	1993	21
1988	Compilation of anatomical, physiological and metabolic characteristics for a reference Asian man (RCA)	1993	11

Safety of nuclear installations

WANO

The trend toward the internationalization of nuclear safety continued in 1989. In June, the IAEA signed a memorandum of understanding with the recently established World Association of Nuclear Operators (WANO).

Basic principles and criteria

INSAG

The Agency's International Nuclear Safety Advisory Group (INSAG) turned its attention to clarifying the nuclear safety implications of the anticipated revision of ICRP recommendations on the dose limitation system. Also, since nearly all Member States operating or constructing nuclear power plants are active in the OSART programme, INSAG undertook a review of the programme and identified areas where improvements would further enhance effectiveness.

Safety of future nuclear installations

At the International Workshop on the Safety of Nuclear Installations of the Next Generation and Beyond (sponsored jointly with the Government of the United States of America through Argonne National Laboratory and held in Chicago), the expert consensus was that a substantially expanded use of nuclear power would call for a correspondingly higher level of safety at all nuclear fuel cycle installations worldwide. The development of reactors with enhanced safety features and simpler, more economic engineering and manufacturing features was seen as an important step in this direction. Irrespective of these developments, the participants agreed that the best strategy for gaining utility and regulatory acceptance of the next generation(s) of nuclear power plants would be a consistent and universal track record of safe, reliable and cost-effective operation of today's nuclear power plants. The presentations and summary reports of discussions are in publication.

Nuclear fusion safety

The Agency convened the fourth in a series of international technical meetings on fusion safety (in Jackson Hole, Wyoming, USA, hosted by the Idaho National Engineering Laboratory). The participants suggested that the Agency explore ways of assisting Member States to compile fusion specific component failure data and of providing guidance based on case study experience with modest upgrading of existing data collection schemes. The proceedings are in publication.

Safety standards and criteria

A select number of Safety Guides are being updated to reflect major technological advances. At its meeting in April, the Nuclear Safety Standards Advisory Group (NUSSAG) approved the technical content of two of the revised guides from the operations area. The first deals with the maintenance of nuclear power plants, specifically the safety aspects. The second deals with the surveillance of items important to safety in nuclear power plants.

Regulatory practices: symposium proceedings

The proceedings of an international symposium on Regulatory Practices and Safety Standards for Nuclear Power Plants, organized jointly with the Federal Republic of Germany and the OECD/NEA, were published. From the discussions it was evident that the vast majority of members of the nuclear community considered it better not to internationally harmonize regulatory practices, but rather to understand the differences within the context of each country's legal

Regulatory practices: symposium proceedings (cont.)

and industrial structure and to use this knowledge to promote consistency among regulatory approaches to common safety objectives. Towards this end, in December the Agency held the first in a planned series of multilateral regulatory peer discussions at which a small group of nuclear regulators from three countries compared good regulatory practices and recommended practical ways of increasing communication among the broader regulatory community.

Publications

Series and No.	Title
Proceedings Series	Regulatory practices and safety standards for nuclear power plants

Safe siting, design and construction of nuclear installations

Comprehensive safety assessments

The Agency has expanded its service activities to include comprehensive safety assessments. Upon request, international and interdisciplinary expert teams assembled by the Agency completed a two part review of the prototype nuclear district heating plant at Gorky in the USSR prior to plant startup. During May–June, a team of 16 experts reviewed the plant's safety design concept, including an assessment of the results of the PSA study. This was followed by a pre-OSART mission in August by 14 experts who focused on construction and preparations for future operation. The final step in the independent safety review took place in November, with the presentation of the Agency's final report to the Soviet authorities.

The two additional units under construction at the Yonggwang nuclear power plant in the Republic of Korea are uniquely designed with scaled down features of a much larger unit operating in the United States of America. Following a request, the Agency assisted the Korean Nuclear Safety Center in reviewing the possible safety implications of these features. The review, which spanned a four week period and involved experts from five countries, identified no major safety concerns in the evaluated areas where these new features would have a potential safety impact.

International Convention on Physical Protection

In February 1987, the International Convention on the Physical Protection of Nuclear Material entered into force. To facilitate co-operation between the Parties with respect to the Convention, the Agency maintains a list of contact points. The Agency's involvement with the issue of physical protection dates back to the early 1970s. A document embodying recommendations issued in 1977 has become a standard reference work. The Agency issued a revision of these recommendations (INFCIRC/225/Rev. 2), which reflects a broad consensus among Member States on the requirements to be met by systems for physical protection. It was guided in this work by the members of a technical committee on physical protection of nuclear material.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Seismic data for the siting and site revalidation of nuclear facilities	1991	6

Publications

Series and No.	Title
IAEA-TECDOC-489	Safety aspects of water chemistry in light water reactors

Safe operation of nuclear installations

Operational safety services

The Operational Safety Review Team (OSART) missions for 1986–1989 are listed in the following table. Of the 11 visits in 1989, three were pre-operational missions, to China, Poland and the Soviet Union, the latter as a component of the comprehensive safety assessment of the prototype nuclear district heating plant at Gorky. As part of the revision process of OSART guidelines and reference material, the Agency published a review of surveillance activities in nuclear power plants and finalized for publication similar documents on reviewing industrial safety and computer applications in nuclear power plants (IAEA-TECDOC-503). A summary report on expert observations from recent OSART missions was issued as IAEA-TECDOC-497.

OSART missions, 1986–1989

1986 Total visits: 6	1987 Total visits: 9	1988 Total visits: 6	1989 Total visits: 11
Finland Germany, Fed. Rep. of Korea, Rep. of Mexico Netherlands Sweden	Canada Germany, Fed. Rep. of (2) Italy Mexico (2) Netherlands Spain USA	France Hungary Italy Japan Sweden USSR	Brazil China Czechoslovakia Italy Korea, Rep. of Pakistan Poland Sweden UK USA USSR

Safety related events: reporting, analysis and communication

Resolving an operating problem at one nuclear power plant can enhance the understanding of safety problems that may be common to specific plant types or generic to all plants. International experts participating this year in the Agency's service to advance operational safety, the Assessment of Safety Significant Events Team (ASSET) programme, visited nuclear power plants in Pakistan and the Soviet Union in response to government requests for assistance in systematically analysing both the root causes of safety related events at these plants and the effectiveness of steps taken to prevent their recurrence. Used independently, the ASSET methodology has proved to be a powerful tool to enhance operational safety. For example, this methodology has recently become a standard analytical procedure in the Soviet Union for reporting safety related operational events at all nuclear power plants.

IRS

The Incident Reporting System (IRS) facilitates an international exchange of reliable information about nuclear power incidents and malfunctions, as is done with the OECD/NEA, with which it has exchanged reports and convened joint meetings. Although more active participation is desirable, the 189 reports received in 1989 brought the database to more than 800 incidents. To support the IRS strategy of providing assistance to Member States in strengthening national reporting systems or developing new systems consistent with the IRS, the Agency published guidelines on systems for reporting unusual events in

IRS (cont.)

nuclear power plants (IAEA Safety Series No. 93). To help ease the problem of judging the severity of safety related events, several Member States have developed or are devising severity scales that would classify events according to their significance. The Agency, together with the OECD/NEA, is working to define a common severity scale for use when communicating nuclear events to the public. A jointly sponsored meeting held in Paris in October added considerable momentum to this work. A draft scale, including sufficient underlying criteria to ensure its consistent operation in different countries, is expected to be ready by mid-1990 for trial use in voluntary open reporting of new events. It is envisaged that, once approved, the scale would be offered to Member States for a trial period.

INSARR

Through its long standing programme of Integrated Safety Assessments of Research Reactors (INSARR), the Agency has provided advice periodically on enhancing the operational safety of reactors set up with its assistance. The programme also responded to government requests for INSARR missions to reactors in Viet Nam and Hungary.

Symposium on research reactors

The safety related problems of research reactor ageing, as well as those of design and construction, were among the issues discussed at the first ever international symposium on research reactors, held in Chalk River, Canada, under the auspices of the the Atomic Energy of Canada Limited and the IAEA. The proceedings are in publication.

The Agency published the results of an earlier CRP on the use of PSA in analysing the safety features of research reactors, as illustrated by reference to national case studies (IAEA-TECDOC-517). A major finding of this international effort was the dearth of databases suitable for use in numerical safety evaluations of research reactors. To help overcome this deficiency, the Agency initiated a CRP on data acquisition for probabilistic safety assessment studies of research reactors. The first meeting of representatives of the dozen participating countries led to a clearly defined strategy for systematically collecting and classifying reliable data that can support safety assessments.

Nuclear power plant ageing

Over the next decade, more than 200 nuclear power plants will pass the 25 year mark. Concerns such as component ageing and its safety implications, together with the fact that in many Member States regulatory policies on nuclear power plant ageing are not fully formulated or documented, led to a technical meeting in November at which specialists from 13 countries, the CEC, OECD/NEA and WANO addressed the issues of record keeping for monitoring the ageing of plant components and structures and explored strategies for maintaining safety margins. Work began on collating information on national studies of ageing mechanisms and their management by surveillance and maintenance as the basis for forthcoming guidance on regulatory policies and practices. Other activities under way include the classification of plant components and methodologies for the operational management of critical components.

Fire safety

Since the major fire at the Browns Ferry nuclear power plant in the USA nearly 15 years ago, the nuclear industry has introduced more stringent criteria for fire safety. Specifically, the lessons learned from fighting the fires during the Chernobyl accident and the Soviet assessment of the situation presented at the IAEA's Post-Accident Review Meeting in 1986 prompted the Agency to organize an international symposium on fire protection and fire fighting at nuclear installations. Held in March, the meeting drew on the expertise of nuclear engineers and conventional fire protection specialists to recommend

Fire safety (cont.)

measures to further improve fire prevention and fire fighting preparedness, particularly for fire conditions coupled with high radiation fields. An important development was in analysis methodology. Computer modelling of fires and their effect on the surroundings allow a much better prediction of the possible consequences to safety equipment. Probabilistic analysis techniques have shown that there is a potential for core melts to be initiated by fires. Improvements in cable insulation to retard the spread of fires have been introduced worldwide and have been verified by independent tests.

The American Nuclear Society, the Finnish Fire Protection Association, the Hungarian Fire Protection Service, the Society of Fire Protection Engineers of the USA, the ISO, and the OECD/NEA were co-sponsors of the meeting. The proceedings have been published.

CRPs established in the current year

Subject	No. of years	Participating institutions
Data acquisition for research reactor PSA studies	9	2

Training courses and seminars held

Course name	Location	No. of participants	Duration
Safety in nuclear power plant operation	France	9	4 weeks
Safety in nuclear power plant operation with PWR/WWER	Czechoslovakia	15	5 weeks

Publications

Series and No.	Title
IAEA-TECDOC-497	OSART results II (a summary of the results of operational safety review team missions during the period June 1987 to May 1988)
IAEA-TECDOC-503	Reviewing surveillance activities in nuclear power plants (supplementary guidance and reference material for IAEA operational safety review teams (OSARTs))
IAEA-TECDOC-517	Application of probabilistic safety assessment to research reactors (report prepared within the framework of an IAEA co-ordinated research programme)
Proceedings Series	Feedback of operational safety experience from nuclear power plants
Proceedings Series	Fire protection and fire fighting in nuclear installations
Safety Series No. 93	Systems for reporting unusual events in nuclear power plants

Accident management and mitigation

Strategies for accident management

The CRP initiated this year on containment structure integrity and effectiveness for accident conditions beyond design basis seeks to promote information exchange on containment performance under severe accident conditions and to stimulate research and development of containment systems.

To help broaden the knowledge base on severe accident analysis at nuclear power plants, the Agency sponsored the first ever international training course on a broad spectrum of issues associated with accident management. Twenty-eight professionals took part in the course held in Argonne, Illinois. In related developments, a series of meetings held this year added thrust to the pioneering work of compiling a comprehensive user manual on accident management in nuclear power plants. Plant vulnerability assessments and the translation of accident management strategies into symptom oriented emergency operating procedures are among the subjects covered in this draft publication.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Severe accident management	1991	10

CRPs established in the current year

Subject	No. of years	Participating institutions
Containment, integrity and effectiveness for accident conditions beyond design basis	3	3

Training courses and seminars held

Course name	*Location*	No. of participants	*Duration*
Accident management in nuclear power plants	USA	28	4 weeks

Safety assessment techniques

PSA

In line with the growing interest in Member States in conducting probabilistic safety assessments (PSAs) at nuclear power plants, the Agency broadened its support activities for planning, performance, peer review and application of PSA study results. The main emphasis is on level-1 PSAs, which estimate the probability of core damage and identify contributing accident sequences and constituent failures.

Training and research

To help remedy the shortage of expertise in PSA performance, the Agency sponsored two training courses, respectively, in Spain and the Soviet Union. Technical expertise has also been enhanced through participation in an ongoing CRP for which three groups from 17 countries performed probabilistic modelling of a reference accident sequence for a WWER, a CANDU reactor and a Framatome reactor type.

PSAPACK

There is as yet no international consensus on quantitative probabilistic safety criteria for setting safety targets. An Agency published technical document (IAEA-TECDOC-524) seeks to contribute to this development. To make the often voluminous results of a PSA more concise and accessible, the first in a series of reports was published this year that draws on actual experience in peer review of a specific PSA (IAEA-TECDOC-522). To enhance operational safety, the personal computer software package developed for event- and fault-tree analysis (PSAPACK) is being adapted to enable operating personnel, regulatory inspectors and others to maintain a 'living' document based on the continuous updating and easy retrieval of information useful for safety decisions. The reliability database included in PSAPACK was published as IAEA-TECDOC-508.

IPERS

The International Peer Review Service (IPERS) for PSAs of nuclear power plants was recently initiated to bring requested international experience to the review process. At the request of the Government of the Netherlands, in August the Agency undertook the first of a three stage IPERS mission to the Borssele nuclear power plant, at which a utility selected contractor is conducting a PSA over an 18 month period. The Agency reviewed both the PSA specification prepared by the utility and thereafter the proposal of the awarded contractor. A short training course on PSA reviews was held for members of the national regulatory authority. As follow-up to an earlier pre-IPERS mission, an Agency assembled team visited China to provide guidance to national specialists conducting a level-1 PSA of the Guangdong nuclear power plant. Additionally, an IPERS mission was undertaken in conjunction with the design review of the Gorky nuclear heating plant in the Soviet Union.

Human reliability analysis

To better understand the human contribution to risk, safety specialists are increasingly exploring the techniques of human reliability analysis as part of a systematic safety assessment approach at nuclear power plants. The task of quantifying, even roughly, human reliability and error is especially challenging. In February, the Agency held a Technical Committee meeting which, through its guidance on human error classification and data collection, laid the foundation for a CRP on the development of human reliability databases that will begin in 1990.

Man-machine interface

In 1988, the Agency sponsored the International Conference on the Man-Machine Interface in the Nuclear Industry and published the proceedings. Among the topics explored was the 'young' science of expert systems, or more

Man–machine interface (cont.)

precisely, knowledge based systems, and how this technique could be more dynamically applied at nuclear power plants to upgrade worker knowledge. As follow-up, the Agency agreed to conduct a CRP in 1990 aimed at promoting the development of expert systems and their use in supporting operation, maintenance, training and other key areas at nuclear power plants.

Comparative assessments of energy risks

Properly viewed, the level of risk nuclear power poses to human health and the environment compares favourably with that of viable energy alternatives. To help provide this perspective, the Agency recently initiated a programme on Comparative Assessments of Nuclear Power with Alternatives. The goal is a reliable and authoritative database on different types of health and environmental impacts posed by the total cycle of the energy systems. Work began on compiling this information and on defining a strategy for promoting the integration of such information into energy planning. In December, agreement was reached with a number of international and regional organizations to jointly sponsor a Senior Expert Symposium on Electricity and the Environment, to be held in 1991. The symposium, a joint effort with the Division of Nuclear Power, will seek a better understanding of the environmental and health effects of different methods of electricity generation and of how this knowledge can be translated into practical policies and practices.

Interagency risk management project

The Agency is working with UNEP, UNIDO and WHO to assess the health and environmental risks from energy and other complex industrial systems; the Agency serves as the secretariat for this interagency project. This represents a pioneering international effort to develop an integrated approach to the management of risks associated with both routine operations and accidents in large industrial areas. Towards this end, 12 collaborative case studies are at various stages of implementation in the European and Latin American regions. To support this work, the Agency is also developing a risk management procedure guide. Meetings held throughout the year have advanced the guide to the final draft stage, suitable for publication in 1990.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Data collection and analysis for probabilistic safety assessments	1991	11
1988	Reference studies on probabilistic modelling of accident sequences	1992	18

Training courses and seminars held

Course name	Location	No. of participants	Duration
Applications of probabilistic safety assessment to nuclear power plant operation	Spain	14	6 weeks
Probabilistic safety assessment (PSA) for nuclear power plant safety	USSR	15	4 weeks

Publications

Series and No.	Title
IAEA-TECDOC-499	Models and data requirements for human reliability analysis
IAEA-TECDOC-504	Evaluation of reliability data sources
IAEA-TECDOC-505	Analysis and management of risks for the nuclear fuel cycle
IAEA-TECDOC-508	Survey of ranges of component reliability data for use in probabilistic safety assessment
IAEA-TECDOC-522	A probabilistic safety assessment peer review: Case study on the use of probabilistic safety assessment for safety decisions
IAEA-TECDOC-523	Probabilistic safety criteria at the safety function/system level
IAEA-TECDOC-524	Status, experience and future prospects for the development of probabilistic safety criteria
IAEA-TECDOC-529	User requirements for decision support systems used for nuclear power plant accident prevention and mitigation

Safeguards

Safeguards statement

In 1989, as in previous years, the Secretariat, in carrying out the safeguards obligations of the Agency, did not detect any event which would indicate the diversion of a significant amount of safeguarded nuclear material — or the misuse of facilities, equipment or non-nuclear material subject to safeguards — for the manufacture of any nuclear weapon, or for any other military purpose, or for the manufacture of any other nuclear explosive device, or for purposes unknown. (In the case of voluntary-offer agreements with nuclear-weapon States, nuclear material subject to safeguards was not withdrawn from safeguards except in conformity with these agreements.) It is considered reasonable to conclude that the nuclear material under Agency safeguards in 1989 remained in peaceful nuclear activities or was otherwise adequately accounted for. This statement is based on all the information available to the Agency, including information derived from safeguards activities conducted in the field and at Headquarters and information provided in reports submitted by States.

Safeguards coverage

As of 31 December 1989, 172 safeguards agreements were in force with 101 States, compared to 168 agreements with 98 States (and with Taiwan, China) at the end of 1988:

Algeria: a unilateral submission agreement covering a research reactor entered into force provisionally in February and the first inspection was successfully carried out (the agreement entered into force definitively on 9 April 1990);

USA: a safeguards agreement pursuant to Additional Protocol I of the Treaty of Tlatelolco entered into force in April;

China: a safeguards agreement pursuant to the voluntary offer by China to place some of its civilian nuclear facilities under Agency safeguards entered into force in September;

India: a unilateral submission agreement covering nuclear material supplied by France entered into force in October; and

Bhutan: a safeguards agreement pursuant to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) entered into force in October.

An agreement between the United States of America, Japan and the Agency expired in accordance with the terms of the agreement for co-operation between the two States.

On 5 April 1989 Spain acceded to the safeguards agreement of 5 April 1973 between the non-nuclear-weapon States of the European Atomic Energy Community (EURATOM), EURATOM itself and the Agency (INFCIRC/193).

Safeguards agreements pursuant to NPT were concluded with the Lao People's Democratic Republic, Tunisia and Viet Nam, and a safeguards agreement pursuant to NPT and the Treaty of Tlatelolco was concluded with Antigua and Barbuda. These agreements had not entered into force by the end of the year (though the agreements with Tunisia and Viet Nam entered into force in early 1990).

In 1989, safeguards were applied in 42 States under agreements pursuant to NPT or to NPT and the Treaty of Tlatelolco, in one State under an agreement pursuant to the Treaty of Tlatelolco and in eleven States under INFCIRC/66/Rev.2-type agreements. (The Agency also applies safeguards to nuclear installations in Taiwan, China).

Number of states having significant nuclear activities at the end of the year indicated

	Number of States		
	1987	1988	1989
States with safeguards applied under NPT or NPT/Tlatelolco agreements	41	41	42
States with safeguards applied under Tlatelolco agreements	1	1	1
States with safeguards applied under INFCIRC/66/Rev.2-type agreements[a]	10	10	10
Nuclear-weapon States with safeguards applied under voluntary-offer agreements	4	4	4
Other nuclear-weapon States	1	1	1
Total number of States with significant nuclear activities	57	57	58

[a] Some States with INFCIRC/66/Rev.2-type agreements which have not yet been suspended, although NPT 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.

Safeguards coverage (cont.)

In the States that have concluded INFCIRC/153-type agreements with the Agency, safeguards were applied to all peaceful nuclear activities. In some of the eleven States where safeguards were being applied pursuant to INFCIRC/66/Rev.2-type agreements, unsafeguarded facilities were known to be in operation or under construction. All nuclear-weapon States have unsafeguarded nuclear fuel cycles.

Voluntary-offer agreements were in force with the five nuclear-weapon States. In accordance with the agreements with four of these States, certain facilities were designated by the Agency for inspection and were inspected. In one of the four States, safeguards were also applied at some facilities under INFCIRC/66/Rev.2-type agreements. Preparations for the implementation of safeguards pursuant to the voluntary-offer agreement concluded with the fifth nuclear-weapon State were initiated.

Status of agreements pursuant to treaty obligations

As of 31 December 1989, safeguards agreements were in force with 82 States pursuant to NPT. In April, Spain acceded to the safeguards agreement of 5 April 1973 between the non-nuclear-weapon States of the European Community, EURATOM and the Agency (INFCIRC/193), and in October the safeguards agreement with Bhutan entered into force. For 51 non-nuclear-weapon States party to NPT there is still no safeguards agreement in force in accordance with Article III.4 of the Treaty. As far as the Agency is aware, only three of these States have significant nuclear activities. Safeguards were being applied in these three States pursuant to other agreements pending the entry into force of a safeguards agreement pursuant to NPT.

Nineteen of the 23 Latin American States party to the Treaty of Tlatelolco have concluded agreements with the Agency pursuant to this Treaty, 16 of which are in force. Two States with territories in the zone of application of the Treaty of Tlatelolco have also concluded similar agreements.

NPT safeguards agreements have been concluded with 10 of the 11 signatories of the South Pacific Nuclear Free Zone Treaty (Rarotonga Treaty), and safeguards were applied in one of these States pursuant to such an agreement.

Situation on 31 December 1989 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
Antigua and Barbuda[b]	1 November 1981	Approved by the Board, June 1989	
Australia	23 January 1973	In force: 10 July 1974	217
Austria	27 June 1969	In force: 23 July 1972	156
Bahamas	10 July 1973		
Bahrain	5 November 1988		
Bangladesh	27 September 1979	In force: 11 June 1982	301
Barbados	21 February 1980		
Belgium	2 May 1975	In force: 21 February 1977	193
Belize	9 August 1985	Approved by the Board, Feb.1986	
Benin	31 October 1972		
Bhutan	23 May 1985	In force: 24 October 1989	371
Bolivia[b]	26 May 1970	Signed: 23 August 1974	
Botswana	28 April 1969		
Brunei Darussalam	25 March 1985	In force: 4 November 1987	
Bulgaria	5 September 1969	In force: 29 February 1972	178
Burkina Faso	3 March 1970		
Burundi	19 March 1971		
Cameroon	8 January 1969		
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		
Colombia	8 April 1986		
Congo	23 October 1978		
Costa Rica[b]	3 March 1970	In force: 22 November 1979	278
Côte d'Ivoire	6 March 1973	In force: 8 September 1983	309
Cyprus	10 February 1970	In force: 26 January 1973	189
Czechoslovakia	22 July 1969	In force: 3 March 1972	173
Democratic Kampuchea	2 June 1972		
Democratic People's Republic of Korea	12 December 1985		
Democratic Yemen	1 June 1979		
Denmark[c]	3 January 1969	In force: 21 February 1977	193
Dominica	10 August 1984		
Dominican Republic[b]	24 July 1971	In force: 11 October 1973	201
Ecuador[b]	7 March 1969	In force: 10 March 1975	231
Egypt	26 February 1981	In force: 30 June 1982	302
El Salvador[b]	11 July 1972	In force: 22 April 1975	232
Equatorial Guinea	1 November 1984	Approved by the Board, June 1986	
Ethiopia	5 February 1970	In force: 2 December 1977	261

Table (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)
Fiji	14 July 1972	In force: 22 March 1973	192
Finland	5 February 1969	In force: 9 February 1972	155
Gabon	19 February 1974	Signed: 3 December 1979	
Gambia	12 May 1975	In force: 8 August 1978	277
German Democratic Republic	31 October 1969	In force: 7 March 1972	181
Germany, Federal Republic of	2 May 1975	In force: 21 February 1977	193
Ghana	5 May 1970	In force: 17 February 1975	226
Greece[d]	11 March 1970	Accession: 17 December 1981	193
Grenada	19 August 1974		
Guatemala[b]	22 September 1970	In force: 1 February 1982	299
Guinea	29 April 1985		
Guinea-Bissau	20 August 1976		
Haiti[b]	2 June 1970	Signed: 6 January 1975	
Holy See	25 February 1971	In force: 1 August 1972	187
Honduras[b]	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[b]	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
Kenya	11 June 1970		
Kiribati	18 April 1985		
Korea, Republic of	23 April 1975	In force: 14 November 1975	236
Kuwait	17 November 1989		
Lao People's Democratic Republic	20 February 1970	Approved by the Board, Feb. 1989	
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
Luxembourg	2 May 1975	In force: 21 February 1977	193
Madagascar	8 October 1970	In force: 14 June 1973	200
Malawi	18 February 1986		
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		
Mauritius	25 April 1969	In force: 31 January 1973	190
Mexico[b]	21 January 1969	In force: 14 September 1973	197
Mongolia	14 May 1969	In force: 5 September 1972	188

Table (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)
Morocco	27 November 1970	In force: 18 February 1975	228
Nauru	7 June 1982	In force: 13 April 1984	317
Nepal	5 January 1970	In force: 22 June 1972	186
Netherlands[e]	2 May 1975	In force: 21 February 1977	193
New Zealand	10 September 1969	In force: 29 February 1972	185
Nicaragua[b]	6 March 1973	In force: 29 December 1976	246
Nigeria	27 September 1968	In force: 29 February 1988	358
Norway	5 February 1969	In force: 1 March 1972	177
Panama[b]	13 January 1977	Signed : 22 December 1988	
Papua New Guinea	25 January 1982	In force: 13 October 1983	312
Paraguay[b]	4 February 1970	In force: 20 March 1979	279
Peru[b]	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[f]	15 December 1977	Accession: 1 July 1986	193
Qatar	3 April 1989		
Romania	4 February 1970	In force: 27 October 1972	180
Rwanda	20 May 1975		
St.Lucia	28 December 1979	Approved by the Board, June 1988	
St. Vincent and the Grenadines	6 November 1984		
Samoa	17 March 1975	In force: 22 January 1979	268
San Marino	10 August 1970	Approved by the Board, Feb.1977	
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
Solomon Islands	17 June 1981		
Somalia	5 March 1970		
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[b]	30 June 1976	In force: 2 February 1979	269
Swaziland	11 December 1969	In force: 28 July 1975	227
Sweden	9 January 1970	In force: 14 April 1975	234
Switzerland	9 March 1977	In force: 6 September 1978	264
Syrian Arab Republic	24 September 1969		
Thailand	7 December 1972	In force: 16 May 1974	241
Togo	26 February 1970		
Tonga	7 July 1971	Approved by the Board, Feb.1975	
Trinidad and Tobago	30 October 1986		
Tunisia	26 February 1970	Signed: 24 February 1989	
Turkey	17 April 1980	In force: 1 September 1981	295
Tuvalu	19 January 1979	Approved by the Board, Feb.1986	

Table (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)
Uganda	20 October 1982		
Uruguay[b]	31 August 1970	In force: 17 September 1976	157
Venezuela[b]	26 September 1975	In force: 11 March 1982	300
Viet Nam	14 June 1982	Signed: 2 October 1989	
Yemen Arab Republic	14 May 1986		
Yugoslavia	3 March 1970	In force: 28 December 1973	204
Zaire	4 August 1970	In force: 9 November 1972	183

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

[c] 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.

[d] The application of Agency safeguards in Greece under the agreement INFCIRC/166, provisionally in force since 1 March 1972, was suspended on 17 December 1981, at 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.

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

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

Situation on 31 December 1989 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	Approved by the Board, June 1989	
Bahamas	26 April 1977		
Barbados	25 April 1969		
Bolivia[b]	18 February 1969	Signed : 23 August 1974	
Colombia	6 September 1972	In force: 22 December 1982	306
Costa Rica[b]	25 August 1969	In force: 22 November 1979	278
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	20 June 1975		
Guatemala[b]	6 February 1970	In force: 1 February 1982	299
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, c]	20 September 1967	In force: 14 September 1973	197
Nicaragua[b]	24 October 1968	In force: 29 December 1976	246
Panama[d]	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
Suriname[b]	10 June 1977	In force: 2 February 1979	269
Trinidad and Tobago	27 June 1975		
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:[e]			
	Netherlands	In force: 5 June 1975	229
	United States of America	In force: 6 April 1989	366

[a] The information reproduced in columns (1) and (2) was taken from the relevant OPANAL status report.

In addition to the States listed in column (1), Argentina has signed the Treaty but not ratified it, while Brazil and Chile have ratified it but have not yet become parties to the Treaty as they have not so far made the declaration provided for in Article 28 of the Treaty. Dominica signed the Treaty on 2 May 1989.

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

[c] 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).

[d] An agreement has also been concluded in 1988 pursuant to both the Treaty of Tlatelolco and NPT, which has not yet entered into force.

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

Agreements providing for safeguards, other than those in connection with NPT or the Treaty of Tlatelolco, approved by the Board as of 31 December 1989

Party(ies)[a]	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.)			
(a) *Project agreements*			
Argentina	Siemens SUR-100	13 March 1970	143
	RAEP Reactor	2 December 1964	62
Chile	Herald Reactor	19 December 1969	137
Finland[b]	FiR-1 Reactor	30 December 1960	24
	FINN sub-critical assembly	30 July 1963	53
Greece[b]	GRR-1 Reactor	1 March 1972	163
Indonesia[b]	Additional core-load for TRIGA Reactor	19 December 1969	136
Iran, Islamic Republic of[b]	UTRR Reactor	10 May 1967	97
Jamaica[b]	Fuel for research reactor	25 January 1984	315
Japan[b]	JRR-3	24 March 1959	3
Malaysia[b]	TRIGA-II Reactor	22 September 1980	287
Mexico[b]	TRIGA-III Reactor	18 December 1963	52
	Siemens SUR-100	21 December 1971	162
	Laguna Verde Nuclear Power Plant	12 February 1974	203
Morocco[b]	Fuel for research reactor	2 December 1983	313
Pakistan	PRR Reactor	5 March 1962	34
	Booster rods for KANUPP	17 June 1968	116
Peru[b]	Research reactor and fuel therefor	9 May 1978	266
Philippines[b]	PRR-1 Reactor	28 September 1966	88
Romania[b]	TRIGA Reactor	30 March 1973	206
	Experimental fuel elements	1 July 1983	307
Spain[b]	Coral-I Reactor	23 June 1967	99
Thailand[b]/United States of America	Fuel for research reactor	30 September 1986	342
Turkey[b]	Sub-critical assembly	17 May 1974	212
Uruguay[b]	URR Reactor	24 September 1965	67
Venezuela[b]	RV-1 Reactor	7 November 1975	238
Viet Nam[c]	Fuel for research reactor	1 July 1983	308
Yugoslavia[b]	TRIGA-II Reactor	4 October 1961	32
	Krško Nuclear Power Plant	14 June 1974	213
Zaire[b]	TRICO Reactor	27 June 1962	37
(b) *Unilateral submissions*			
Algeria	Research reactor	23 February 1989 (provisionally)	361
Albania	All nuclear material and facilities	25 March 1988	359
Argentina	Atucha Power Reactor Facility	3 October 1972	168
	Nuclear material	23 October 1973	202
	Embalse Power Reactor Facility	6 December 1974	224
	Equipment and nuclear material	22 July 1977	250
	Nuclear material, material, equipment and facilities	22 July 1977	251
	Atucha II Nuclear Power Plant	15 July 1981	294
	Heavy water plant	14 October 1981	296
	Heavy water	14 October 1981	297
	Nuclear material	8 July 1982	303

Table (cont.)

Party(ies)[a]	Subject	Entry into force	INFCIRC
Chile	Nuclear material	31 December 1974	256
	Nuclear material	22 September 1982	304
	Nuclear material	18 September 1987	350
Cuba	Nuclear research reactor and fuel therefor	25 September 1980	298
	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 for this reactor	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
Pakistan	Nuclear material	2 March 1977	248
Spain	Nuclear material[d]	18 June 1975	221
	Vandellos Nuclear Power Plant[d]	11 May 1981	292
	Specified nuclear facilities[d]	11 May 1981	291*
United Kingdom	Nuclear material	14 December 1972	175
Viet Nam	Research reactor and fuel therefor	12 June 1981	293
(c) *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
Union of Soviet Socialist Republics	Nuclear material in facilities selected from list of facilities provided by the USSR	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
(d) *Other agreements*			
Argentina/United States of America		25 July 1969	130
Austria[d]/United States of America		24 January 1970	152
Brazil/Germany, Federal Republic of[d]		26 February 1976	237
Brazil/United States of America		31 October 1968	110
Colombia/United States of America		9 December 1970	144
India/Canada[d]		30 September 1971	211
India/United States of America		27 January 1971	154
Iran, Islamic Republic of[d]/ United States of America		20 August 1969	127
Israel/United States of America		4 April 1975	249
Japan[d]/Canada[d]		20 June 1966	85
Japan[d]/France		22 September 1972	171

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

Table (cont.)

Party(ies)[a]	Subject	Entry into force	INFCIRC
Japan/United Kingdom		15 October 1968	125
Korea, Republic of/ United States of America		5 January 1968	111
Korea, Republic of[d]/France		22 September 1975	233
Pakistan/Canada		17 October 1969	135
Pakistan/France		18 March 1976	239
Philippines[d]/United States of America		19 July 1968	120
Portugal[d]/United States of America[e]		19 July 1969	131
South Africa/United States of America		26 July 1967	98
South Africa/France		5 January 1977	244
Spain/Germany, Federal Republic of[d]		29 September 1982	305
Spain/United States of America		9 December 1966	92
Spain/Canada[d]		10 February 1977	247
Sweden[d]/United States of America		1 March 1972	165
Switzerland[d]/United States of America[e]		28 February 1972	161
Turkey[d]/United States of America[e]		5 June 1969	123
Venezuela[d]/United States of America[e]		27 March 1968	122

(e) 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 are non-governmental. The agreements are implemented by the Agency on that basis.

[a] An entry in this column does 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.

[b] Agency safeguards are being applied to the items required to be safeguarded under this (these) project agreement(s) pursuant to an agreement in connection with NPT covering the State indicated.

[c] The requirement for the application of safeguards under this agreement is satisfied by the application of safeguards pursuant to the agreement of 12 June 1981 (INFCIRC/293).

[d] 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.

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

Planning, direction, co-ordination, control and evaluation

SAGSI

Two regular and two working group meetings were held by the Standing Advisory Group on Safeguards Implementation (SAGSI) in order to complete its advice on long term guidelines for future safeguards activities. Advice on both INFCIRC/153-type and INFCIRC/66 Rev.2-type agreements has now been provided. At the first of the two regular meetings the Agency presented a new method to be used in organizing its research and development programme. SAGSI provided advice on this method and at its second meeting considered a comprehensive long term progress report on the use of this method.

Effectiveness evaluation

An evaluation of inspection goal attainment for 1988 was made according to the safeguards criteria and the results reported to the Board of Governors in the Safeguards Implementation Report (SIR). The criteria were communicated to Member States to facilitate their assessment of the credibility of the Agency's verification procedures and to contribute to co-operation between the States and the Agency in applying safeguards. The SIR was presented in a new format designed to clarify the presentation of information on the essential aspects of safeguards.

The preparation of unified safeguards implementation and evaluation criteria continued, account being taken of recommendations provided by the Standing Advisory Group on Safeguards Implementation (SAGSI) on long term guidelines for inspection goal attainment and current practices, criteria and policies.

Support programmes

On the basis of recommendations arising from the Safeguards Support Programme Review, the transfer to Member States of certain tasks arising from the co-ordination and implementation of Support Programmes was initiated and the administrative structure was reorganized to ensure that the priorities identified by the Agency are used to govern the safeguards R&D projects carried out under Support Programmes. An important feature of this new process is the emphasis placed on a product oriented client-developer relationship between the Department of Safeguards and the Member State Support Programmes. A Support Programme Information and Communication System (SPRICS) has been established to increase management efficiency and improve communications.

Additional support provided by Member States

States and organizations representing groups of States having formal support programmes (initiated in the year indicated)		States having R&D contracts and test programmes
Australia	1989	Argentina
Belgium	1982	Austria
Canada	1977	Bulgaria
European Atomic Energy Community	1981	Czechoslovakia
Finland	1988	Hungary
France	1983	Pakistan
German Democratic Republic	1988	Switzerland
Germany, Federal Republic of	1978	Yugoslavia
Italy	1985	
Japan	1981	
Sweden	1987	
USSR	1982	
United Kingdom	1980	
United States of America	1976	

Safeguards operations

Verification

In carrying out its verification activities, the Agency found a number of discrepancies and anomalies. These were mostly minor and were satisfactorily explained upon subsequent appraisal or investigation.

Specific inspection activities included:

- A simultaneous physical inventory verification covering unirradiated low enriched uranium (LEU) in all facilities in the LEU fuel cycle was carried out for the first time in one State.
- Verification of the transfer of spent fuel into long term dry storage canisters using specially designed measurement methods complemented by containment and surveillance of transport.
- Cost effective verification of exceptionally large throughput carried out at a complex, advanced fuel fabrication plant by short notice random inspections.

The development of new or modified safeguards approaches continued with the co-operation of the States concerned. The developments included:

- An approach for safeguarding LWRs using mixed oxide (MOX) fuel, based on observation and containment and surveillance (C/S) measures to maintain continuity of knowledge of previously verified MOX fuel, was implemented in a number of States.
- A safeguards approach for a prototype fast breeder reactor under construction was developed, with the aim of having the necessary instrumentation in place before startup.
- A new safeguards approach was implemented at a complex plutonium conversion plant; certain refinements are under discussion.
- Significant progress was made in the development of a safeguards approach for a criticality test facility presently under construction.
- A safeguards approach for a hot cell complex in one State was developed.

After discussion with States, new safeguards equipment and techniques were introduced in a number of facilities:

- The Cerenkov viewing device designed for verification of irradiated fuel was introduced for routine use at LWRs in one more State.
- The neutron collar detector for verification of unirradiated fuel was implemented at LEU fuel fabrication facilities in two more States.
- Acceptance tests were completed and routine use agreed for an operator's X ray fluorescence analysis system intended for measuring plutonium concentrations in solutions.
- An underwater closed circuit television (CCTV) system provided by the operator was approved for routine use by the Agency at a reprocessing plant. At the same facility, a new spiking technique for input accountability samples was successfully tested and will be implemented in 1990. The new technique is designed to improve sample handling procedures and to reduce delays.
- The cascade header enrichment monitor was successfully demonstrated at one plant. In another State preparation for commissioning a similar device has reached an advanced stage.
- A new personal computer (PC) version of the software for plutonium mass verification using high level neutron coincidence counters was developed and installed in several facilities. This software is designed to replace the data acquisition performed by the HP-85 system, permitting data storage on diskette for retrieval and analysis.

Verification (cont.)

— An improved algorithm for measuring plutonium isotopes using gamma ray spectroscopy was incorporated into routine data reduction methods at several facilities.

Negotiation and liaison with States

Committees and other regular contact between the Agency and Member States, including working arrangements with facility operators, helped to further improve safeguards implementation:

— The IAEA offices in Toronto and Tokyo continued to make a significant contribution to effective safeguards implementation. Negotiations were concluded with Japan on extending the functions of the Tokyo Office to those of a Regional Office.

— Continuous progress was made in the negotiation of Subsidiary Arrangements. Two General Parts of Subsidiary Arrangements (zero in 1988) and 88 (35 new and 53 revised) Facility Attachments (49 in 1988) entered into force, some of which had been under negotiation for more than five years. The negotiation of the General Part of the Subsidiary Arrangements required under the voluntary offer agreement with a nuclear-weapon State was completed. Negotiation of the facility attachments for two major conversion plants was completed.

— Liaison was intensified with one State on matters concerning design information, design information verification, safeguards approach and the provision and installation of instrumentation for a nuclear power station with five CANDU-type units currently under construction.

— Safeguards concepts for a natural uranium dioxide conversion plant and for a LEU-hexafluoride conversion laboratory were developed and the facility attachments drafted and submitted to the States.

— Following the development of a safeguards approach, discussions were held with a nuclear-weapon State on the application of safeguards under the voluntary offer agreement at the receipt and storage ponds of a large reprocessing facility.

— A safeguards concept for a liquid metal cooled fast breeder reactor was developed and negotiations on the facility attachment continued.

Safeguards inspection verification activities

	1987	1988	1989
Inspections performed	2 133	2 128	2 196
Person-days of inspection	9 556	9 379	10 132
Seals applied to nuclear material or Agency safeguards equipment detached and subsequently verified at Headquarters	12 500	15 500	13 500
Plutonium and uranium samples analysed	1 340	1 170	1 200
Analytical results reported	3 600	3 040	2 890
Major facilities at which inspection goals were attained for the whole facility	214	248	254

Approximate quantities of material subject to Agency safeguards at the end of 1989

Type of material	Quantity of material (t)			
	INFCIRC/153[a]	INFCIRC/66[b]	Nuclear-weapon States	Quantity in SQ
Nuclear material				
Plutonium[c] contained in irradiated fuel	197.0[d]	19.8	68.0	35 606
Separated plutonium outside reactor cores	8.4	0	5.2	1 695
Recycled plutonium in fuel elements in reactor cores	1.1	0	0	136
HEU (equal to or greater than 20% uranium-235)	10.5	0.3	0	252
LEU (less than 20% uranium-235)	24 606	1 994	7 233	10 399
Source material[e] (natural or depleted uranium and thorium)	36 519	2 710	17 905	4 325
Total significant quantities				*52 413*
Non-nuclear material[f]				
Heavy water	0	1 457	0	73

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

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

[c] The quantity includes an estimated 63.9 t (7987 SQ) of plutonium in irradiated fuel, which is not reported to the Agency under the agreed reporting procedures (the non-reported plutonium is contained in irradiated fuel assemblies to which item accountancy and C/S measures are applied).

[d] Includes 9 t (1125 SQ) of plutonium previously included in the inventory of a State under INFCIRC/66/Rev.2-type agreements and which has not yet been covered by INFCIRC/153-type State reports.

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

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

Number of installations under safeguards or containing safeguarded material on 31 December 1989

Installation category	Number of installations			
	INFCIRC/153[a]	INFCIRC/66 Rev. 2[b]	Nuclear-weapon States	Total[c]
Power reactors	166	16	1	183 (188)
Research reactors and critical assemblies	148	24	1	173 (172)
Conversion plants	5	3	0	8 (7)
Fuel fabrication plants	33	8	2	43 (41)
Reprocessing plants	4	1	0	5 (6)
Enrichment plants	5	1	1	7 (7)
Separate storage facilities	36	4	5	45 (41)
Other facilities	48	3	0	51 (49)
Subtotals	445	60	10	515 (511)
Other locations	376	29	0	405 (407)
Non-nuclear installations	0	2	0	2 (2)
Totals	821	91	10	922 (920)

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

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

[c] Numbers for 1988 are indicated in parentheses for comparison.

Facilities under Agency safeguards or containing safeguarded material on 31 December 1989

Power reactors

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Argentina	Atucha NPS	Lima	x
	Embalse PR	Embalse	—
Belgium	BR3	Mol	x
	DOEL-1	Doel	x
	DOEL-2	Doel	x
	DOEL-3	Doel	x
	DOEL-4	Doel	x
	Tihange-1	Tihange	x
	Tihange-2	Tihange	x
	Tihange-3	Tihange	x
Brazil	Angra-1	Angra dos Reis	x
Bulgaria	Kozloduy-I, Unit 1	Kozloduy	x
	Kozloduy-I, Unit 2	Kozloduy	x
	Kozloduy-II, Unit 1	Kozloduy	x
	Kozloduy-II, Unit 2	Kozloduy	x
	Kozloduy-III, Unit 1	Kozloduy	x
Canada	Bruce A, Unit 1	Tiverton	x
	Bruce A, Unit 2	Tiverton	x
	Bruce A, Unit 3	Tiverton	x
	Bruce A, Unit 4	Tiverton	x
	Bruce B, Unit 5	Tiverton	x
	Bruce B, Unit 6	Tiverton	x
	Bruce B, Unit 7	Tiverton	x
	Bruce B, Unit 8	Tiverton	x
	Darlington A, Unit 2	Bowmanville	—
	Gentilly-2	Gentilly	x
	Pickering A, Unit 1	Pickering	x
	Pickering A, Unit 2	Pickering	x
	Pickering A, Unit 3	Pickering	x
	Pickering A, Unit 4	Pickering	x
	Pickering B, Unit 5	Pickering	x
	Pickering B, Unit 6	Pickering	x
	Pickering B, Unit 7	Pickering	x
	Pickering B, Unit 8	Pickering	x
	Point Lepreau G.S.	Point Lepreau	x
Czechoslovakia	Al	Bohunice	x
	Dukovany-2, Unit 1	Dukovany	x
	Dukovany-2, Unit 2	Dukovany	x
	EDU-1, Unit 1	Dukovany	x
	EDU-1, Unit 2	Dukovany	x
	V-1, Unit 1	Bohunice	x
	V-1, Unit 2	Bohunice	x
	V-2, Unit 1	Bohunice	x
	V-2, Unit 2	Bohunice	x

Power reactors (cont.)

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Finland	Loviisa-1	Loviisa	x
	Loviisa-2	Loviisa	x
	TVO-1	Olkiluoto	x
	TVO-2	Olkiluoto	x
German Democratic Republic	Bruno Leuschner-I, Unit 1	Greifswald	x
	Bruno Leuschner-I, Unit 2	Greifswald	x
	Bruno Leuschner-II, Unit 3	Greifswald	x
	Bruno Leuschner-II, Unit 4	Greifswald	x
	Bruno Leuschner-III, Unit 5	Greifswald	—
	Rheinsberg PWR	Rheinsberg	x
Germany, Federal Republic of	AVR	Jülich	—
	GKW Grohnde	Grohnde	—
	GKN-2	Neckarwestheim	x
	KKW Biblis-A	Biblis	x
	KKW Biblis-B	Biblis	x
	KKW Brokdorf	Brokdorf	—
	KKW Brunsbüttel	Brunsbüttel	x
	KKW Emsland	Lingen	x
	KKW Grafenrheinfeld	Grafenrheinfeld	—
	KKW Isar	Ohu bei Landshut	x
	KKW Isar-2	Essenbach	—
	KKW Krümmel	Geesthacht	x
	KKW Mülheim-Kärlich	Mülheim-Kärlich	x
	KKW Neckarwestheim	Neckarwestheim	x
	KKW Obrigheim	Obrigheim	x
	KKW Philippsburg-1	Philippsburg	x
	KKW Philippsburg-2	Philippsburg	—
	KKW RWE-Bayernwerk II, Block B	Gundremmingen	x
	KKW RWE-Bayernwerk II, Block C	Gundremmingen	x
	KKW Stade	Stade	x
	KKW Unterweser	Stadland	x
	KKW Würgassen	Würgassen	x
	KFK-MZFR	Eggenstein-Leopoldshafen	x
	KKW SNR-300	Kalkar	—
	KNK	Eggenstein-Leopoldshafen	x
	Thorium Hochtemperatur Reaktor	Hamm	—
Hungary	PAKS-I, Unit 1	Paks	x
	PAKS-I, Unit 2	Paks	x
	PAKS-II, Unit 1	Paks	x
	PAKS-II, Unit 2	Paks	x
India	RAPS Unit 1	Rajasthan	x
	RAPS Unit 2	Rajasthan	x
	TAPS Unit 1	Tarapur	x
	TAPS Unit 2	Tarapur	x
Italy	ENEL	Borgo-Sabatino	x
	C.N. del Garigliano	Sessa Aurunca	x
	C.N. Caorso	Caorso	x
	C.N. Enrico Fermi	Trino-Vercellese	x

Power reactors (cont.)

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Japan	Fugen	Tsuruga-Fukui	x
	Fukushima Dai-Ichi-1	Okuma-Fukushima	x
	Fukushima Dai-Ichi-2	Okuma-Fukushima	x
	Fukushima Dai-Ichi-3	Okuma-Fukushima	x
	Fukushima Dai-Ichi-4	Okuma-Fukushima	x
	Fukushima Dai-Ichi-5	Okuma-Fukushima	x
	Fukushima Dai-Ichi-6	Okuma-Fukushima	x
	Fukushima Dai-Ni-1	Naraha-Fukushima	x
	Fukushima Dai-Ni-2	Naraha-Fukushima	x
	Fukushima Dai-Ni-3	Naraha-Fukushima	x
	Fukushima Dai-Ni-4	Naraha-Fukushima	x
	Genkai-1	Kyushu	x
	Genkai-2	Kyushu	x
	Hamaoka-1	Hamaoka-cho	x
	Hamaoka-2	Hamaoka-cho	x
	Hamaoka-3	Hamaoka-cho	x
	Ikata-1	Nishiuwa-gun	x
	Ikata-2	Nishiuwa-gun	x
	Kashiwazaki-1	Niigata	x
	Kashiwazaki-2	Niigata	x
	Kashiwazaki-5	Niigata	x
	Mihama-1	Mihama-Fukui	x
	Mihama-2	Mihama-Fukui	x
	Mihama-3	Mihama-Fukui	x
	Ohi-1	Ohi-cho, Fukui-ken	x
	Ohi-2	Ohi-cho, Fukui-ken	x
	Onagawa-1	Miyaki-ken	x
	Sendai-1	Sendai	x
	Sendai-2	Sendai	x
	Shimane-1	Kashima-cho	x
	Shimane-2	Kashima-cho	x
	Takahama-1	Takahama	x
	Takahama-2	Takahama	x
	Takahama-3	Takahama	x
	Takahama-4	Takahama	x
	Tokai-1	Tokai-Mura	x
	Tokai-2	Tokai-Mura	x
	Tomari-1	Tomari-Mura	x
	Tsuruga-1	Tsuruga	x
	Tsuruga-2	Tsuruga	x
Korea, Republic of	Kori-1	Pusan	x
	Kori-2	Pusan	x
	Kori-3	Pusan	x
	Kori-4	Pusan	x
	Uljin-1	Uljin	x
	Uljin-2	Uljin	x
	Wolsung-1	Ulsan	x
	Youngwang 1	Pusan	x
	Youngwang 2	Pusan	x
Mexico	Laguna Verde 1	Alto Lucero	x

Power reactors (cont.)

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Netherlands	Borssele	Borssele	x
	Dodewaard NPP	Dodewaard	x
Pakistan	KANUPP	Karachi	x
Philippines	PNPP-1	Morong, Bataan	x
South Africa	Koeberg-1	Cape Town	x
	Koeberg-2	Cape Town	x
Spain	Almaraz-1	Almaraz	—
	Almaraz-2	Almaraz	—
	Asco-1	Asco	—
	Asco-2	Asco	—
	Cofrentes	Cofrentes	—
	José Cabrera	Almonazid de Zorita	—
	Santa María de Garona	Santa María de Garona	—
	Trillo-1	Trillo	—
	Vandellos 1	Vandellos	—
	Vandellos 2	Vandellos	—
Sweden	Barsebäck I	Malmö	x
	Barsebäck II	Malmö	x
	Forsmark I	Uppsala	x
	Forsmark II	Uppsala	x
	Forsmark III	Uppsala	x
	Oskarshamn I	Oskarshamn	x
	Oskarshamn II	Oskarshamn	x
	Oskarshamn III	Oskarshamn	x
	Ringhals I	Göteborg	x
	Ringhals II	Göteborg	x
	Ringhals III	Göteborg	x
	Ringhals IV	Göteborg	x
Switzerland	KKB-I	Beznau	x
	KKB-II	Beznau	x
	KKG	Gösgen-Däniken	x
	KKL	Leibstadt	x
	KKM	Mühleberg	x
Union of Soviet Socialist Republics	Novo Voronezh Unit 5	Novo Voronezh	x
Yugoslavia	Křsko	Krško	x

Research reactors and critical assemblies

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Algeria	NUR Reactor	Wilaya de Tipaza	—
Argentina	RA-1	Constituyentes	x
	RA-2	Constituyentes	x
	RA-3	Ezeiza	x
	RA-4	Rosario	x
	RA-6	Bariloche	x
	RA-O	Cordoba	—
Australia	HIFAR	Lucas Heights	x
	MOATA	Lucas Heights	x
	CF	Lucas Heights	x
Austria	ASTRA	Seibersdorf	x
	SAR	Graz	x
	Triga II	Vienna	x
Bangladesh	Atomic Energy Research Est.	Ganakbari Savar Dhaka	x
Belgium	BRO2	Mol	x
	BR1-CEN	Mol	x
	BR2-CEN	Mol	x
	CEN-Venus	Mol	x
	Thetis	Gent	x
Brazil	IEAR-1	São Paulo	x
	RIEN-1	Rio de Janeiro	x
	Triga-CDTN	Belo Horizonte	x
Bulgaria	IRT-2000	Sofia	x
Canada	McMaster	Hamilton	x
	NRU	Chalk River	x
	NRX	Chalk River	x
	PTR	Chalk River	x
	Slowpoke-AECL	Ottawa	x
	Slowpoke-Dalhousie Univ.	Halifax	x
	Slowpoke-Ecole Polytechnique	Montreal	x
	Slowpoke-Saskatchewan	Saskatoon	x
	Slowpoke-Toronto University	Toronto	x
	Slowpoke-Univ. of Alberta	Edmonton	x
	Slowpoke-Kingston	Kingston	—
	WR-1	Pinawa	x
	ZED-2	Chalk River	x
Chile	La Reina	Santiago	x
	Lo Aguirre	Santiago	x
Colombia	IAN-R1	Bogotá	x
Czechoslovakia	LR-O	Řež	x
	SR-OD	Vochov	x
	Univ. Training Reactor VR-1P	Prague	x
	VVR-S	Řež	x
Democratic People's Republic of Korea	Critical assembly	Nyonphyon	x
	IRT-DPRK	Nyonphyon	x
Denmark	DR-1	Roskilde	x
	DR-3	Roskilde	x

Research reactors and critical assemblies (cont.)

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Egypt	Nuclear Research Centre	Inshas	x
Finland	Triga II	Otaniemi	x
German Democratic Republic	RAKE	Rossendorf	x
	RRR	Rossendorf	x
	Training Reactor AKR	Dresden	x
	Training research reactor	Zittau	x
	WWR-S M	Rossendorf	x
Germany, Federal Republic of	FMRB	Braunschweig	x
	FRF-2	Frankfurt	x
	FRM	Garching	x
	GKSS-FRG1	Geesthacht	x
	GKSS-FRG2	Geesthacht	x
	KFA-FRJ1	Jülich	x
	KFA-FRJ2	Jülich	x
	SUR 100	Bremen	x
	SUR 100	Eggenstein-Leopoldshafen	x
	SUR 100	Hannover	x
	SUR 100	Kiel	x
	SUR 100	Hamburg	x
	SUR 100	Ulm	x
	SUR 100	Stuttgart	x
	SUR 100	Furtwangen	x
	SUR 100	Darmstadt	x
	SUR 100	Aachen	x
	Triga	Mainz	x
	Triga	Hannover	x
	Triga II	Heidelberg	x
	BER-2	Berlin (West)[b]	x
	SUR 100	Berlin (West)[b]	x
Greece	GRR-1	Attiki	x
Hungary	Training reactor	Budapest	x
	WWR-S M	Budapest	x
	ZR-6	Budapest	x
Indonesia	Gama	Yogyakarta	x
	MPR-30	Serpong	x
	PPTN	Bandung	x
Iran, Islamic Republic of	TSPRR	Teheran	x
Iraq	IRT-5000	Baghdad Tuwaitha	x
	Tamuz-2	Baghdad Tuwaitha	x
Israel	IRR-1	Soreq	x
Italy	AGN-201	Palermo	x
	CESNEF-L54	Milan	x
	ESSOR	Ispra	x
	RB-3	Montecuccolino	x
	RTS-1	San Piero a Grado	x
	TAPIRO	Santa Maria di Galeria	x
	Triga-RC1	Santa Maria di Galeria	x
	Triga-2	Pavia	x

Research reactors and critical assemblies (cont.)

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Jamaica	Centre for Nuclear Sciences	Kingston	x
Japan	DCA	Oarai-Machi	x
	FCA	Tokai-Mura	x
	HTR	Kawasaki-shi	x
	JMTR	Oarai-Machi	x
	JMTR-CA	Oarai-Machi	x
	JOYO	Oarai-Machi	x
	JRR-2	Tokai-Mura	x
	JRR-3	Tokai-Mura	x
	JRR-4	Tokai-Mura	x
	Kinki University R.R.	Kowake	x
	KUCA	Kumatori-cho	x
	KUCA	Kumatori-cho	x
	KUCA	Kumatori-cho	x
	KUR	Kumatori-cho	x
	Musashi College R.R.	Kawasaki	x
	N.S. Mutsu	Minato-Machi	x
	NAIG-CA	Kawasaki-ku	x
	NSRR	Tokai-Mura	x
	Rikkyo University R.R.	Nagasaka	x
	TCA	Tokai-Mura	x
	TODAI	Tokai-Mura	x
	TTR	Kawasaki-shi	x
	VHTRC	Tokai-Mura	x
Korea, Republic of	Triga II	Seoul	x
	Triga III	Seoul	x
	Kyung-Hee Univ.	Seoul	x
Libyan Arab Jamahiriya	IRT-Tajura	Tajura	x
Malaysia	Puspati	Bangi, Selangor	x
Mexico	Triga III	Ocoyoacac	x
	SUR 100	Mexico City	x
Netherlands	HOR	Delft	x
	HFR	Petten	x
	LFR	Petten	x
Norway	HBWR-Halden	Halden	x
	JEEP-II	Kjeller	x
Pakistan	PARR	Rawalpindi	x
Peru	Centro nucl. de investigaciones	San Borja	—
	RP-O	Lima	x
Philippines	PRR-1	Diliman, Quezon City	x
Poland	Agata	Świerk	x
	Anna	Świerk	x
	Ewa	Świerk	x
	Maria	Świerk	x
	Maryla	Świerk	x
Portugal	RPI	Sacavem	x

Research reactors and critical assemblies (cont.)

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Romania	RP-01	Magurele	x
	Triga II	Piteşti Colibaşi	x
	VVR-S	Magurele	x
South Africa	SAFARI-1	Pelindaba	x
Spain	ARBI	Bilbao	—
	ARGOS	Barcelona	—
	CORAL-1	Madrid	—
	JEN-1 and JEN-2	Madrid	—
Sweden	R2	Studsvik	x
	R2-O	Studsvik	x
Switzerland	AGN 201P	Geneva	x
	AGN 211P	Basel	x
	Crocus	Lausanne	x
	Proteus	Würenlingen	x
	Saphir	Würenlingen	x
Thailand	TRR-1	Bangkok	x
Turkey	TR-1	Istanbul	x
	ITU-TRR	Istanbul	x
Union of Soviet Socialist Republics	IR-8 Research Reactor	Moscow	x
Uruguay	Lockheed	Montevideo	x
Venezuela	RV-I	Altos de Pipe	x
Viet Nam	Da-Lat Research Reactor	Da Lat	—
Yugoslavia	RA	Vinča	x
	RB	Vinča	x
	Triga II	Ljubljana	x
Zaire	Triga-Zaire	Kinshasa	x

Conversion plants, including pilot plants

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Argentina	UO_2 Conversion Plant	Cordoba	—
	Uranium Powders Fabrication Plant	Constituyentes	—
Canada	CAMECO	Port Hope	x
Japan	Japan Nuclear Fuel		
	Conversion Co. Ltd.	Tokai-Mura	x
	Ningyo R + D	Ningyo	x
	PCDF	Tokai-Mura	x
Mexico	UO_2 Conversion Plant	Salazar	—

Fuel fabrication plants, including pilot plants

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Argentina	Atucha Fuel Fabrication Plant	Ezeiza	—
	Fuel Fabrication Plant (CANDU)	Ezeiza	—
	Pilot Fuel Fabrication Plant (HEU)	Constituyentes	x
	Research Reactor Fuel Fab. Plant	Constituyentes	—
Belgium	Belgonucléaire-BN-MOX	Dessel	x
	FBFC	Dessel	x
	FBFC MOX Assembling Facility	Dessel	—
Brazil	Fuel Fabrication Plant Resende	Resende	x
Canada	GEC	Peterborough	x
	GEC	Toronto	x
	CRNL Fuel Fabrication	Chalk River	x
	Zircatec P.I. Ltd.	Port Hope	x
Denmark	Metallurgy	Roskilde	x
Germany, Federal Republic of	Exxon	Lingen	x
	NUKEM	Wolfgang	x
	Siemens Uran	Hanau	x
	Siemens Uran	Karlstein	x
	Siemens MOX	Hanau	x
India	EFFP-NFC	Hyderabad	x
Indonesia	Experimental Fuel Element Installation (IEBE)	Serpong	x
	Research Reactor Fuel Element Production Installation (IPEBRR)	Serpong	x
Iraq	ERLFF	Baghdad Tuwaitha	x
Italy	COREN	Saluggia	x
	Fabnuc	Bosco Marengo	x
	IFEC	Saluggia	x
Japan	JNF	Yokosuka	x
	MNF	Tokai-Mura	x
	NFI (Kumatori-1)	Kumatori, Osaka	x
	NFI (Kumatori-2)	Kumatori, Osaka	x
	NFI (Tokai) Fuel Fabrication	Tokai-Mura	x
	PFPF	Tokai-Mura	x
	PPFF	Tokai-Mura	x
Korea, Republic of	CFFP	Daejeon	x
	LEU Fuel Fabrication	Daejeon	x
Mexico	Fuel Fabrication Plant	Ocoayacac	—
Romania	Romfuel	Piteşti Colibaşi	x
Spain	CIEMAT Planta Metall.	Madrid	—
	ENUSA Fuel Fabrication Plant	Juzbado	—
Sweden	ASEA-ATOM	Västeras	x
United States of America	General Electric Co.	Wilmington, N.C.	x
	Babcock & Wilcox Co.	Lynchburg, Va.	x

Chemical reprocessing plants, including pilot plants

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Germany, Federal Republic of	WAK	Eggenstein-Leopoldshafen	x
India	PREFRE	Tarapur	x
Italy	EUREX	Saluggia	x
	ITREC-Trisaia	Rotondella	x
Japan	Tokai Reprocessing Plant	Tokai-Mura	x

Enrichment plants, including pilot plants

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Brazil	Sep. Noz. Enrichment Plant	Resende	—
Germany, Federal Republic of	Uranit*	Jülich	—
	URENCO Deutschland, UTA-1	Gronau	x
Japan	Uranium Enrichment Plant	Ningyo	x
Netherlands	Ultra-Centrifuge*	Almelo	—
	URENCO Nederland	Almelo	x
United Kingdom	BNFL Centrifuge plant and associated storage	Capenhurst	x

* Location associated with enrichment technology.

Separate storage facilities

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Argentina	Storage of depleted hexafluoride	Bariloche	—
	Storage of 20% enriched uranium	Cac	—
Belgium	BN UF6 store	Dessel	x
	Belgoprocess	Mol	x
	FBFC	Dessel	—
Bulgaria	AFRS	Kozloduy	—
Canada	Bruce A	Tiverton	x
	Bruce B	Tiverton	x
	CRNL	Chalk River	x
	CRNL spent fuel dry store	Chalk River	—
	Douglas Point	Tiverton	x
	Gentilly-1	Gentilly	x
	Long term storage at CRNL	Chalk River	—
	Pickering	Pickering	x
	WNRE	Pinawa	x
Chile	Lab. experimental de conversión	Santiago	—
Czechoslovakia	AFRS	Bohunice	x
Denmark	Risø Store	Roskilde	x
Finland	Long term storage for TVO	Olkilouto	—
France	COGEMA UP2 spent fuel storage ponds	La Hague	—
German Democratic Republic	Interim storage facility for spent fuel assemblies	Greifswald	—
Germany, Federal Republic of	Bundeslager	Wolfgang	—
	Exxon Nuclear UF6 Lageranlage	Lingen	x
	KFK-FR-2	Eggenstein-Leopoldshafen	x
	KFA Jülich Lager (AVR Kugeln)	Jülich	x
	LSG UF_6 Freilager	Hanau	—
	TNH GesmbH	Landsbergen-Leese	—
	TNH GesmbH	Hanau	—
	Urananlage	Birkenfeld	x
Iraq	Separate storage facility	Baghdad Tuwaitha	x
Italy	Avogadro	Saluggia	x
	Deposito Prodotti Uraniferi	Bosco Marengo	x
	Ispra Central Storage	Ispra	x
	Lab. di Misura Nucleare Perla	Ispra	—
Japan	KUFFS	Kyoto	x
Luxembourg	International Metals S.A.	Luxembourg-Dommeldange	x
Pakistan	Storage at Government depot	Karachi Malir	x
Portugal	Instalação de Armazenagem	Sacavem	x
Spain	ENUSA Almacen UF_6	Saelices	—
Sweden	Central long term storage	Oskarshamn	—
Switzerland	Diorit Storage	Würenlingen	x
United Kingdom	BNF PLC Store 9	Sellafield	x
	Sellafield Pu-storage	Sellafield	x
	Oxide Fuel Storage Pond	Sellafield	x
	THORP	Sellafield	—

Other facilities

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Argentina	Labo. de Calificación	Constituyentes	—
Australia	Research Laboratory	Lucas Heights	x
Belgium	BCMN	Geel	x
	CEN-Labo	Mol	x
	CEN-WASTE	Mol	—
	I.R.E.	Fleurus	x
	PULAB	Mol	x
Canada	Physics, Chemistry, Fuel Eng., Health Phys., R+D	Chalk River	x
Czechoslovakia	Nuclear Fuel Inst. (UJP)	Zbraslav	x
	Research Laboratories	Řež	x
Denmark	Hotcell Plant	Roskilde	x
German Democratic Republic	Uran Technikum	Rossendorf	—
Germany, Federal Republic of	KFA-heisse Zellen	Jülich	x
	Institut für Kernphysik-1	Eggenstein-Leopoldshafen	x
	KFK-heisse Zellen	Eggenstein-Leopoldshafen	x
	KFK/IHCH	Eggenstein-Leopoldshafen	x
	KFK/IMF3	Eggenstein-Leopoldshafen	x
	KWU-heisse Zellen	Karlstein	x
	Lab. d. KFA Jülich	Jülich	x
	Transuran	Eggenstein-Leopoldshafen	x
Hungary	Institute of Isotopes	Budapest	x
Italy	CNEN-LAB. PU.	Santa Maria di Galeria	x
	CNEN-LAB. TEC.	Santa Maria di Galeria	x
	ESSOR	Ispra	—
	Joint Research Centre	Ispra	—
Japan	JAERI-Oarai R&D	Oarai-Machi	x
	JAERI-Tokai R&D	Tokai-Mura	x
	MHI-FL	Tokai-Mura	x
	Mitsubishi Atomic Power Industries	Tokai-Mura	x
	NERL, University of Tokyo	Tokai-Mura	x
	NFD	Oarai-Machi	x
	NFI Tokai II	Tokai-Mura	x
	NRF Neutron Radiation Facility	Tsukuba	x
	PNC FMF	Oarai-Machi	x
	PNC IRAF	Oarai-Machi	x
	PNC-Oarai R&D	Oarai-Machi	x
	PNC Tokai R&D	Tokai-Mura	x
	Uranium material laboratory	Oarai-Machi	x
Korea, Republic of	PIEF	Daejeon	x
Netherlands	ECN+JRC	Petten	x
	Kema Lab.	Arnhem	x
Norway	Research laboratories	Kjeller	x

Other facilities (cont.)

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Poland	Institute of Nuclear Research	Świerk	x
	Miscellaneous locations combined in one material balance area	Various	x
South Africa	Hot Cell Complex	Pelindaba	x
Spain	CIEMAT Lab-U	Madrid	—
	CIEMAT Lab-Pu	Madrid	—
Sweden	Central storage fresh fuel	Studsvik	x
	RO	Studsvik	x
Switzerland	Fed. Inst. of Reactor Research	Würenlingen	x

Non-nuclear installations

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Argentina	Heavy water plant	Arroyito	—
	Heavy water storage	Buenos Aires	x

[a] An entry in this column does 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.

[b] The interests of Berlin (West) are represented within the United Nations system by the Federal Republic of Germany.

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

Safeguards support

Safeguards systems for:
— MOX fuel fabrication plants

The installation of instrumentation at an automated MOX fuel fabrication plant continued, with commissioning of fuel assembly and fuel pin measurement systems, in-process powder, pellet and scrap assay systems, glove box counters and small sample assay systems, based on the neutron coincidence assay technique. Temporary use of an advanced C/S system for the automated MOX powder store was introduced to gain experience. Progress was also made towards the implementation of near-real-time accountancy at the plant, with successful trials of operator and Agency analysis and authentication software. Acceptance tests were completed and agreement reached for the Agency to make routine use of the operator's thermal quadrupole mass spectrometer for on-site plutonium isotopic analyses.

Discussions were started with a group of States to determine the safeguards approach for a new large automated MOX fuel fabrication plant under construction. An analysis was made of safeguards concepts and of the equipment required for the plant. Significant contributions to the concepts were provided through a Member State's support programme.

— multi-unit nuclear power stations

The first core discharge monitoring (CDM) system was installed at a CANDU multi-unit nuclear power station and passed preliminary testing. Results confirmed the expected radiation detection capabilities for background radiation measurements. Short notice random inspections were successfully carried out at the facility pending commissioning of the CDM system.

— heavy water production plants

All the modifications required for later installation of equipment for safeguarding a heavy water production plant were completed. A programme for the preparation, testing and evaluation of equipment and concepts is being discussed with the State concerned.

— reprocessing plants

Discussions on the construction schedule for a large reprocessing plant were held and an overview of the project prepared. A working group was formed and preliminary informal discussions were held regarding an on-site analytical laboratory and inspector work spaces.

The facility attachment for a large spent fuel store of a reprocessing plant in a nuclear-weapon State came into force at the end of the year. Arrangements were made for the design, installation and testing of an extensive C/S system at this installation. The work was carried out in co-operation with Member State support programmes.

System studies

Work continued on the development and implementation of safeguards approaches for large projects. Support was also provided in the practical implementation of safeguards approaches regarding the introduction of an ultrasonic sealing system for spent fuel in CANDU storage bays.

Work was initiated on safeguards approaches for new, large scale reprocessing plants planned for startup in the mid-1990s. An internal project team was established to co-ordinate programme activities. Two subgroups were constituted, one to address generic issues and propose guidelines for establishing policy in the area of reprocessing plant safeguards, and the other to consider facility specific issues.

Equipment management services

	1987	1988	1989
Twin photo units in use	268	268	278
Photo cameras repaired and tested	364	301	288
Twin photo unit failures related to equipment	0.7%	0.8%	0.5%
Surveillance film developed at Headquarters	1794	1658	1860
Seals verified	12 456	15 508	13 543
Shipments of equipment	237	264	354
Shipments of nuclear material and chemicals	123	113	124
Procurement actions	679	892	1240
Samples analysed by SAL and NWAL	1344	1173	1199

System studies (cont.)

The Agency continued participation in multi-national meetings under the auspices of LASCAR (Large Scale Reprocessing Plant Safeguards). Discussions on the spent fuel storage area and the head-end area were completed. Work has started on the second part of LASCAR activities, concerned with the process area and the product storage area of reprocessing plants.

Instrument development and equipment provision

As part of the programme for the replacement of the photographic optical surveillance units, extensive reliability and field commissioning tests of the new CCTV systems (modular integrated video system — MIVS) were successfully completed and the first systems authorized for use in inspection. Procurement orders were placed for the first production units, incorporating the design changes arising from the field commissioning exercises. This project has been accompanied by an extensive quality assurance effort.

The Agency's capability of making in situ plutonium isotopic measurements was substantially enhanced by the introduction of new software, including a very powerful data reduction algorithm and new state-of-the-art electronics that will enhance the accuracy obtainable and shorten the measurement time.

A universal software package for all passive neutron coincidence counters was finalized and is now in routine use.

A field unit that provides tamper indication for television signals sent via unsecured data lines was acquired and is presently under test at a nuclear facility.

The field test of an extensive C/S system which incorporates a portal monitor, intrusion sensors and CCTV cameras was successfully completed at two complex facilities in one State. Functional specifications of the authentication system have been agreed upon and the system is being constructed. The system is designed to reduce the inspection effort by the Agency and the exposure of inspectors and operators to radiation.

Development of the spent fuel attribute system (SFAT) continued. The system should permit in situ verification of spent fuel (LWR or CANDU bundles). One version has been successfully tested after installation at an on-load reactor storage pond.

Instrument development and equipment provision (cont.)

An Advisory Group meeting was held to discuss NDA measurements. It focused on standards and calibration procedures, and produced a report updating information on NDA standards, including a number of recommendations aimed at improving the development, deployment and efficacy of standards for non-destructive measurements for Agency safeguards.

Standardization and quality assurance activities

A total of 2289 inspection reports (2417 in 1988) and 2494 inspection statements (2612 in 1988) were reviewed, and computerized quality control checks applied. Reports on the quality and timeliness of inspection documentation packages were routinely made. The average time required between an inspection and the dispatch of the results to the State concerned was reduced to 50 days (64 in 1988 and 83 in 1987).

The testing of the seals verification activity continued. Within this programme, deliberately altered seals were submitted as a blind test of the Headquarters verification capability. Also, a number of inspection reports were randomly selected and in-depth review of the documentation on surveillance application was performed. Reviews were made of the timeliness of reporting destructive analysis results.

Statistical analysis

Material balance evaluations were made for 80 material balance periods and 72 material balance areas covering verification activities in 53 facilities. The evaluation methodology has been extended to allow for the inclusion of non-destructive verification measurements.

Data necessary to define the quality of measurement systems continued to be collected and analysed. In the past these data were derived primarily from destructive analyses carried out by the Safeguards Analytical Laboratory, the Network Laboratories and operators. The data files have been extended to include results for a number of non-destructive measurement systems. Verification performance estimates developed from these data are used in material balance evaluations, operator–inspector pair evaluations, inspection sample plan calculations and measurement system quality control.

Data processing

The computer configuration was expanded with additional external disk capacity in order to maintain two copies of the database so that the production activities can be separated from application development, leading to increased reliability and safety.

The development and introduction of PC based systems for use by inspectors in the field progressed. A version of the inspection field support system (IFSS) incorporating all the functional requirements was completed, together with system and user documentation. The system is now in routine use at two large facilities and is under consideration at others. The PC based seals system was installed in one Regional Office and at four facilities. This system is designed to keep track of the seals inventory at the sites. A PC based system for automatic processing of measurement data from a high level neutron coincidence counter was developed and released for use by the inspectors.

Significant improvement was achieved in the reliability and effectiveness of the data communication link between Headquarters and the Regional Office in Toronto through the utilization of a packet-switched network. The communication system is routinely used for entering and transmitting inspection data.

New software was developed for the transit matching subsystem, which reduces the clerical effort required and provides for increased quality assurance.

Data processing (cont.)

Computer storage and maintenance of data on the stratification of nuclear material at facilities was achieved. These data are used to plan and conduct inspection activities and to prepare the computerized inspection report (CIR).

A new computerized system was initiated to provide for more effective processing of data sent to the Agency concerning material which has not reached the starting point of safeguards.

The Agency, in consultation with Member States, revised the presentation of information on the promptness of reports which is furnished with the semi-annual statement of book inventory. This information is also used in the preparation of the SIR and of statements sent to States on the conclusions drawn from safeguards inspection activities.

Substantial efforts were spent on the maintenance of the current IAEA Safeguards Information System (ISIS) software to meet additional user requirements, in particular for the safeguards accounting, inspection and management systems, for the quality control of inspection data, for the surveillance reporting system, and for the safeguards implementation and evaluation criteria. Most of the work on the revision of user documentation was completed.

As a follow-up to the recommendations provided by the international group of experts on the enhancement of ISIS, a number of activities were implemented, including a complete redesign of the CIR quality control program (one of the biggest and most complicated parts of the ISIS software) and design of an application monitoring system to provide complete and accurate knowledge of the total computer resources.

Training

Two introductory courses were conducted for new inspectors. They included exercises in the German Democratic Republic and the USSR. Twenty-six advanced and refresher courses for professional staff, as well as individual training in the NDA and C/S areas, were organized at Headquarters and in the field. Substantial support in the organization and conduct of training courses continued to be provided by Member States.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Course for junior professionals from developing countries	Headquarters	5	1 year
Implementation of State Systems for Accounting and Control of Nuclear Material (SSACs) (regional course)	Australia	14	3 weeks
Implementation of State Systems for Accounting and Control of Nuclear Material (SSACs) (advanced course)	USA	25	3 weeks
Seminar on safeguards accounting data	Headquarters	55	1 week

Direction and support

Administration

Amendment to Article VI.A.1 of the Statute

The amendment to Article VI.A.1 of the Agency's Statute providing for the designation by the Board of Governors each year of the 10 — instead of 9 — Member States "most advanced in the technology of atomic energy including the production of source materials" had been accepted by 76 Member States by the end of the year. Thus, the amendment came into force on 28 December 1989, the date on which it had been accepted by two thirds of the Member States.

Conventions relating to nuclear accidents

The Convention on Early Notification of a Nuclear Accident (reproduced in document INFCIRC/335), which entered into force on 27 October 1986, was ratified or approved by 9 States and acceded to by 4 States during 1989. Altogether, there were 72 signatories and 45 parties by the end of the year.

The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (reproduced in document INFCIRC/336), which entered into force on 26 February 1987, was ratified or approved by 8 States and acceded to by 4 States during 1989. Altogether, there were 70 signatories and 40 parties by the end of the year.

Physical Protection Convention

The Convention on the Physical Protection of Nuclear Material (reproduced in document INFCIRC/274/Rev. 1), which entered into force on 8 February 1987, was ratified or accepted by 2 States and acceded to by 1 State during 1989. By the end of the year, 46 States and EURATOM had signed the Convention and 28 States were party to it.

Agreement on the Privileges and Immunities of the IAEA

During 1989, 1 additional State accepted the Agreement on the Privileges and Immunities of the IAEA (reproduced in document INFCIRC/9/Rev. 1), bringing the total number of acceptances to 62.

Agreements relating to liability for nuclear damage

The Vienna Convention on Civil Liability for Nuclear Damage, which entered into force on 12 November 1977, was ratified by 1 more State and acceded to by 2 more States during 1989. By the end of the year, there were 10 signatories and 13 parties.

The Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention, which was opened for signature on 21 September 1988, was signed by 2 States and ratified by 3 States during 1989. By the end of the year, 22 States had signed the Protocol and 3 States had ratified it. The Protocol will enter into force three months after the date of deposit of instruments of ratification, acceptance, approval or accession by at least 5 States party to the Vienna Convention on Civil Liability for Nuclear Damage and 5 States party to the Paris Convention on Third Party Liability in the Field of Nuclear Energy.

In response to Resolution GC(XXXII)/RES/491 of the General Conference, the Board of Governors, at its meeting on 23 February 1989, established an open ended working group to study all aspects of liability for nuclear damage. The working group held two sessions (29 May–1 June 1989 and 30 October–3 November 1989). The report of the first session was considered by the Board

Agreements relating to liability for nuclear damage (cont.)

of Governors at its meetings in September. The report of the second session of the working group, containing suggestions about its future work, will be submitted for consideration by the Board at its meetings in February 1990.

Nuclear legislation advisory services

Advice on nuclear legislation and regulatory activities was provided to China and Morocco to supplement the advice provided in previous years. Advice was also provided to Saudi Arabia on radiation protection legislation.

Matters relating to nuclear safety and radioactive wastes

In response to a suggestion made at the thirty-first session of the General Conference, the Agency compiled and systematized the texts of bilateral, regional and multilateral agreements relating to co-operation in the field of nuclear safety to be published in the Agency's Legal Series in 1990. On the basis of replies received from some 45 countries, the compilation will include texts and other material covering more than 100 agreements.

Pursuant to GC(XXXII)/RES/490, an Expert Group representing 20 Member States and 3 international organizations was established by the Director General. The Group met on 22–25 May to discuss the basic principles of a Code of Practice on Transboundary Movements of Radioactive Wastes. A second meeting of the Group will take place on 5–9 February 1990 to finalize a draft Code for submission to the June 1990 meeting of the Board and the thirty-fourth session of the General Conference.

Personnel

At the end of 1989, the number of members of the Secretariat was 2171 — 825 in the Professional and higher categories, 1202 in the General Service category and 144 in the Maintenance and Operatives Service category. These figures represent: members of the Secretariat occupying manning table posts (1634) or charged to manning table posts (94) or to the temporary assistance fund (98); officials serving on a reimbursement basis (270) or on secondment (2); and Commissary staff (73).

Among the 609 staff members in posts subject to geographical distribution, 76 nationalities were represented. The percentage of female staff in posts subject to geographical distribution was, on 31 December 1989, 11.65%.

Organizational structure

The organizational chart showing the structure of the Secretariat can be found at the end of the Annual Report.

Regular Budget

On the basis of an exchange rate of 12.70 Austrian Schillings to one United States dollar, the General Conference appropriated an amount of $157 540 000 for the Regular Budget. This amount had to be adjusted in accordance with the adjustment formula presented in the attachment to resolution GC(XXXII)/RES/495 in order to take into account the exchange rate actually experienced during the year — 13.18 Austrian schillings to one United States dollar.

The Regular Budget for 1989 at an exchange rate of 13.18 Austrian schillings to one United States dollar amounted to $152 520 000, of which $143 749 000 was to be financed from contributions by Member States on the basis of the 1989 scale of assessment, $5 045 000 from income from work for others and $3 726 000 from other miscellaneous income.

Expenditures

The actual expenditures in 1989 amounted to $147 831 764, resulting in an unencumbered balance of $4 688 236.

Voluntary contributions

The target for voluntary contributions to the Technical Assistance and Co-operation Fund in 1989 was established at $42 million. At the end of the year, $35 680 915 had been pledged by Member States in support of the technical assistance programme.

Extrabudgetary contributions

A total of $20 969 294 was offered in extrabudgetary contributions by Member States, the United Nations and other international organizations during 1989. Of this amount, $8 268 960 was for technical assistance projects, $3 766 087 was in support of safeguards, $2 220 683 was for projects in the field of food and agriculture, $1 779 457 was in support of Funds in Trust and $1 249 763 was for Regional Co-operative Agreements (RCA). The remaining $3 684 344 was in support of various other projects implemented by the Agency.

In addition, extrabudgetary resources amounting to $7 460 242 were donated for the International Centre for Theoretical Physics and $440 191 for the International Laboratory of Marine Radioactivity.

Publications

Series and No.	Title
Legal Series No. 3 (10th edn)	Agreements registered with the International Atomic Energy Agency
	Nuclear liabiliity: Joint protocol relating to the application of the Vienna Convention and the Paris Convention, 1988

Technical co-operation servicing and co-ordination

General issues during 1989

The year under review, 1989, was the first year of the biennial programme. While it is too early to judge the efficacy of the two year cycle, fears that it would be too rigid to respond to changing needs have proved to be unfounded.

In July 1989, the Department of Technical Co-operation was reorganized, the Division of Technical Assistance and Co-operation being split into the Division of Technical Co-operation Programmes (TCPM) and the Division of Technical Co-operation Implementation (TCIM). In conjunction with this reorganization, the Programme Co-ordination Section was moved to the Office of the Deputy Director General, Head of the Department of Technical Co-operation. The arrangement became fully operational in January 1990 with the appointment of a Director for TCIM.

Efforts to computerize further aspects of the administration of the technical co-operation programme continued throughout the year. As a result of the generous donation of equipment by the United States of America and the Republic of Korea, access to computer systems was significantly improved. With the acquisition of new hardware, however, there has been an increased demand for computer programming and maintenance services.

Preparatory work relating to the establishment of a regional co-operative agreement for African Member States (AFRA) was successfully completed with the formulation of a proposed text of the agreement.

The Agency actively participated in on-going interagency discussions concerning the operational activities of the United Nations system as they relate to technical co-operation.

The proportion of women benefitting directly from Agency technical co-operation activities has been steadily increasing. In 1981, for example, 17% of all fellows were women; the corresponding figure for 1989 was 22%. Of the 519 training course participants in 1981, 64 — or 12.3% — were women; in 1989, the figure was 16.8%.

Evaluation

Since its introduction six years ago, evaluation has become an integral part of the Agency's technical co-operation activities and is playing an important role in the effort to make these activities more effective. Regular monitoring of all operational projects through the interim project implementation reporting system continued in 1989. Two major sectoral evaluations and a country evaluation were completed in 1989. Two additional, less extensive country reviews were conducted, and a total of 65 projects underwent mid-project or end of project evaluations. Evaluation activities continued to provide indispensable insights into the Agency's technical co-operation activities.

Programme implementation and trends

A total of 191 new projects were approved as part of the 1989–1990 technical co-operation programme. As 844 projects were already operational at the start of 1989, there were 1035 projects financed from all sources "on the books" on 1 January 1989. In the course of the year, 38 training courses were approved, 35 footnote-a/ projects were made operational and 17 projects were established under the Reserve Fund. In addition, seven new UNDP projects and three special programme projects became operational. These additional 100 projects brought the total number of operational projects in 1989 to 1135 (1009 in 1988).

Programme implementation and trends (cont.)

The provision of technical assistance in 1989 involved arranging for 2144 expert assignments, processing 3894 purchase orders for equipment and supplies, devising training programmes for 924 fellows and visiting scientists, and organizing 106 regional and interregional training courses for 1265 participants, in addition to furnishing general logistic and administrative support.

Technical co-operation programme delivery

	1985	1986	1987	1988	1989
Number of expert assignments	1846	1930	1808	2023	2144
Number of expert person-months served	1585	1516	1356	1239	1246
Number of expert/lecturer assignments undertaken by Agency staff	418	449	407	430	444
Number of purchase orders processed	3391	3738	3701	3386	3894
Number of fellows in the field	615	734	870	682	732
Number of visiting scientists	188	203	160	156	192
Number of participants in training courses	926	972	945	1109	1265

The Technical Divisions of the Secretariat played an active part in supporting technical co-operation activities. During 1989, 172 technical officers provided support of various kinds to the 1135 projects that were operational during the year, undertaking 444 assignments (either as experts or as training course lecturers) for a total of 141 person-months and evaluating 1257 fellowship applications.

The provision of preparatory assistance continued during 1989 under a special project approved by the Board for that purpose. In total, 28 missions were carried out to 25 countries for a total of 12.5 months.

Resources and delivery

Total new resources available for technical co-operation amounted to $50.1 million, which is nearly 10% higher than the figure for the previous year. The Technical Assistance and Co-operation Fund (TACF) accounted for 74.5% of the total available resources, extrabudgetary funds for 14.7%, UNDP for 6.2% and assistance in kind for 4.6%. Pledges and miscellaneous income, reduced by currency exchange losses, covered 88.8% of the TACF target of $42 million (in the previous year, 90.7% of the TACF target of $38 million had been covered). The decline in the percentage of the target pledged which began in 1983 continued in 1989.

The value of the programme planned for implementation (total adjusted programme for 1989) was $66.7 million. Obligations were entered into for goods and services valued at $37.7 million, yielding an overall implementation rate for the programme of 56.5%.

Implementation by resource category

Resource category	Adjusted programme ($)	New obligations ($)	Implementation rate (%)
TACF	48 867 916	28 320 331	58.0
Extrabudgetary	12 510 654	5 842 863	46.7
UNDP	4 427 249	3 105 808	70.2
Funds in trust	914 133	403 321	44.1

Resources and delivery (cont.)

The overall implementation rate, which is an indicator of the technical assistance inputs (experts, fellowships, supply of equipment) started by the Agency in a given year, declined somewhat compared to 1988.

Implementation by assistance component

Component	Adjusted programme ($)	New obligations ($)	Implementation rate (%)
Experts	16 101 763	7 768 737	48.2
Equipment	30 532 933	17 607 301	57.7
Fellowships	9 598 595	5 988 424	62.4
Training courses	8 291 586	4 994 245	60.2
Subcontracts	1 654 629	806 811	48.8
Miscellaneous	540 446	506 805	93.8
Total	66 719 952	37 672 323	56.5

As in the past, disbursements were highest in respect of the equipment component. The share of this component in the total delivery in 1989 was somewhat under 50%; the remaining provisions were nearly evenly split between training and expert services.

Distribution of assistance

Of the assistance delivered in 1989, the largest portion (20.0%) related to physical and chemical sciences, closely followed by food and agriculture (19.9%) and industry and earth sciences (17.2%). Other important areas for the technical co-operation programme in 1989 were nuclear power (10.6%), human health (9.3%) and radiation protection (9.0%).

Assistance provided to various regions

Region	Overall share in %						
	1984	1985	1986	1987	1988	Average 1984–1988	1989
Africa	25.5	20.9	19.9	18.5	21.1	21.2	20.5
Asia and the Pacific	26.7	28.4	26.8	30.0	29.0	28.2	29.5
Europe	11.5	13.1	13.6	18.9	13.9	14.2	13.4
Latin America	24.7	22.7	22.5	20.3	23.0	22.7	25.8
Middle East	0.9	1.6	3.1	2.1	3.0	2.1	2.1
Interregional	10.7	13.4	13.9	9.9	10.0	11.6	8.6

Distribution of assistance (cont.)

The relative shares of Asia and the Pacific and Latin America increased slightly compared to the average during the period 1984–1988, while those of Africa, Europe and the Middle East and interregional assistance declined somewhat. It should be noted, however, that the above figures refer to disbursements from all sources. In the Agency's regular programme of technical co-operation for 1989 as approved by the Board, the regional distribution was as follows: Africa 24%, Asia and the Pacific 25%, Europe 22%, Latin America 23%, the Middle East 4% and interregional 2%.

Specialized service activities

Public information material

The Division continued and expanded its work on producing information material (including brochures, booklets, pamphlets and press releases), arranging exhibits, giving lectures and briefings, and responding to requests and enquiries. To mark the 25th anniversary of the Joint FAO/IAEA Division, a film entitled "Atoms in the Service of Agriculture" was produced. Film material was also supplied for features on IAEA safeguards and the IAEA General Conference for the United Nations film service. Japanese versions of the general information film "For the Benefit of Humanity" and of the film on safeguards "Headquarters Vienna" were produced in Japan.

Special public information booklets

A special booklet on the Agency's contribution to sustainable development, based on a report to the United Nations General Assembly, was produced and widely distributed to government officials, journalists and decision makers. Also prepared for the General Conference was a booklet entitled "Highlights of IAEA Activities", which presented the Agency's work in a popularized annual report format.

Other special booklets produced included those on RCA, the use of nuclear strategies in food and agriculture and the work of the International Centre for Theoretical Physics.

IAEA Bulletin* and *IAEA Newsbriefs

The Agency's worldwide circulation periodicals — the *IAEA Bulletin* and *IAEA Newsbriefs* — were distributed collectively to more than 30 000 readers in Member States. (IAEA Newsbriefs is published regularly in English; abridged versions are translated and published separately in China and Japan.) Additionally, the sixth edition of *IAEA News Features*, a publication which reviews special subjects from a global perspective, was prepared on the decommissioning of nuclear facilities.

Regional seminar

With the help of the Indian authorities, a regional seminar on nuclear power was held in Bombay. It was attended by a large number of journalists, medical specialists, municipal leaders and officials from Bangladesh, India, Iran and Pakistan and was planned as the first in a series of such events to be organized at various locations.

SISPlan

The project to develop a Strategic Plan for Information Support (SISPlan) was completed. The report suggests a number of further studies and as a follow-up, the Agency is evaluating the proposed projects for prioritization and development.

INIS membership

Mongolia joined the International Nuclear Information System (INIS) in 1989.

INIS database on CD-ROM

The first production disk of the INIS database on CD-ROM was produced. It contained records of *INIS ATOMINDEX* from January 1987 to March 1989. The retrieval software will be provided later by the BRS Company in the United States of America.

FIBRE

FIBRE (friendly inputting of bibliographic records), a PC compatible software package for INIS input, was developed by ATOMINFORM, the USSR INIS centre and Centro de Informações Nucleares, the Brazilian INIS centre. It will help INIS input centres to submit their records on diskettes in a more efficient and consistent manner.

Subject scope

The INIS Advisory Committee approved changes in the subject scope of the literature to be covered. The most significant changes are the exclusion of astrophysics and cosmology and the inclusion of economic and environmental aspects of all energy sources, nuclear as well as non-nuclear.

Subject headings

A study on the improvement of the methodology for the selection of subject headings for *INIS ATOMINDEX* was continued.

Input spelling check

Work was started on the development of input programs to check the spelling of the free text portions of the INIS records (title and abstract).

Legal literature

A procedure was established whereby legal texts received for addition to the VIC Library collection are checked for appearance in INIS and follow-up action is undertaken with Member States in the case of those items found missing.

Reference Series

The INIS Descriptive Cataloging Rules and the INIS Descriptive Cataloging Samples were revised. The Authority List for Journal Titles, the Authority List for Corporate Entries and the Thesaurus were updated. A new Reference Series, INIS Guidelines for Standardized Entry of Corporate Bodies (IAEA-INIS-21), was issued.

Computer-output-on microfiche (COM)

All *INIS ATOMINDEX* products (single issues and cumulative indexes) are now available on COM microfiche. Some are only available in microfiche form, such as the 18 year cumulative index (1970–1987). COM operations are significantly reducing INIS printing costs.

On-line microfiche ordering

A new service has been introduced for on-line ordering of full text nuclear literature on microfiche through the INIS Clearinghouse. This improves the ordering procedure and the delivery time and also simplifies the administrative work.

Training courses held

Course name	Location	No. of participants	Duration
INIS human resources development: on-the-job training	USSR	16	2 weeks
INIS training seminar	Headquarters	63	2 weeks

Information about INIS

	1986	1987	1988	1989
Membership Member States Intergovernmental organizations	88 74 14	89 75 14	93 78 15	94 79 15
Number of INIS Members using direct access	28	33	28	27
Records entered in *INIS ATOMINDEX* Non-conventional literature	90 401 26 609	101 118 26 807	106 919 29 479	86 281 24 652
No. of records in *INIS ATOMINDEX*	1 058 038	1 159 156	1 266 075	1 352 356
Number of INIS members receiving output tapes	41	42	43	43
On-line access hours by external users	1 277	1 131	758	773
Microfiche masters				235 000
Microfiche dispatched Full microfiche subscriptions	540 000 37	500 000 37	500 000 37	550 000 37
Number of subscriptions to *INIS ATOMINDEX*	873	828	740	635

Shared support services

VICLINE

With the successful implementation of the VICLINE pilot project, the VIC Library's catalogue of holdings was made available to VIC staff members' offices with access via terminals and personal computers. The pilot project database, updated daily, contained more than 90 000 records of books, selected documents, technical reports and films.

Serials management project

The second phase of the Serials Management Project has been successfully completed with the acquisition of a local area network (LAN) to support the Library's microcomputer based serials check-in and management system. The project gives improved control over the approximately 37 000 journal issues received annually by the Library.

Nuclear film collection

Increased use was made of the Library's collection of films, the majority of which are on the peaceful uses of nuclear energy. Of the 398 films loaned to Member States, films produced by the Joint FAO/IAEA Division in the subject areas of plant breeding and genetic engineering were of special interest. Other films were heavily used in training courses throughout the world.

Information on VIC Library Major Activities

	1986	1987	1988	1989
Records in the Library catalogue	77 770	84 756	90 702	96 419
Books	71 134	73 730	76 929	78 916
Technical reports	535 404	551 304	571 000	592 806
Documents	988 038	1 024 338	1 069 000	1 108 947
Journal titles subscribed to	4 090	4 118	4 168	4 187
Items received as gifts and exchange	2 249	2 263	2 442	2 611
Journal issues checked in	25 313	40 065	40 229	36 795
Journal issues circulated to staff	—	26 724	25 355	22 875
Material loaned to VIC users	8 105	6 345	10 205	11 302
Inquiries responded to	8 738	8 783	8 066	8 569
Interlibrary loan requests	7 636	4 935	7 947	7 324
Current awareness bulletins compiled and distributed	16 063	15 000	16 000	16 200
Photocopies made	263 118	245 900	263 014	308 284
Films loaned to Member States	228	234	304	398
Official visitors and tours	90	132	107	193
Active exchange agreements with other institutions	117	143	152	152

Computer applications development

The most important applications developed were:

(a) On-line microfiche ordering system for INIS;
(b) On-line access to PRIS;
(c) Incident Reporting System on PCs;
(d) Acquisition management and configuration database for following up the status of all data processing equipment in the VIC;
(e) Procurement system on PCs;
(f) Extension of the travel database;
(g) PC vaccination system for Medical Services;
(h) Major rewrite of the software for the Agency's nuclear Emergency Response System (ERS).

Utilization of mainframes

Utilization of the IBM 3083 (dedicated to Safeguards data processing) and of the IBM 3081 (shared by other users) during prime operating hours increased by 15% and 20% respectively. During October, additional memory (16 MB) was installed on the IBM 3081 to handle the increase in utilization, bringing this computer to its maximum configuration.

Office automation and local area networks

Office automation facilities were introduced to more staff in the Departments of Technical Co-operation and Nuclear Energy and Safety. Technical planning and engineering support for the implementation of LANs within the office automation project continued.

External network

Enhancements were made to the external network. A special form of access to EARN (European Academic and Research Network) was implemented for Member States. Feasibility studies were undertaken and technical proposals made to connect the Agency's mainframe computer, via EARN, with ICTP in Trieste and ILMR in Monaco.

Data security

The security procedures for use of databases by internal and external staff have been tightened; ease of access to databases for authorized staff has been improved at the same time.

Storage and printing equipment

Upgrades to the storage and printing equipment were made, thus improving disk access times and increasing the total available on-line disk storage, improving reliability and speed of tape access. A new printer was installed to allow high quality printing output, replacing certain obsolete photocomposition equipment.

Publishing

The Agency continues to act as 'the largest nuclear publisher in the world'. Many of the Advisory Group, Technical Committee and consultants meetings convened by the Agency have the prime objective of developing texts containing the latest scientific, technical or engineering information on nuclear related matters or regulatory or advisory material concerned with radiological or nuclear safety. Much of this material is finally produced and transferred to Member States as priced publications which are also sold on the international book markets or as unpriced documents. In order to ensure that all of these publications maintain a high quality and accuracy consistent with the reputation and authority of the Agency, considerable editing and production work are required.

In 1989, almost 174 separate books or journal issues were published. The net income from the sale of publications was $1 520 971.

Publishing (cont.)

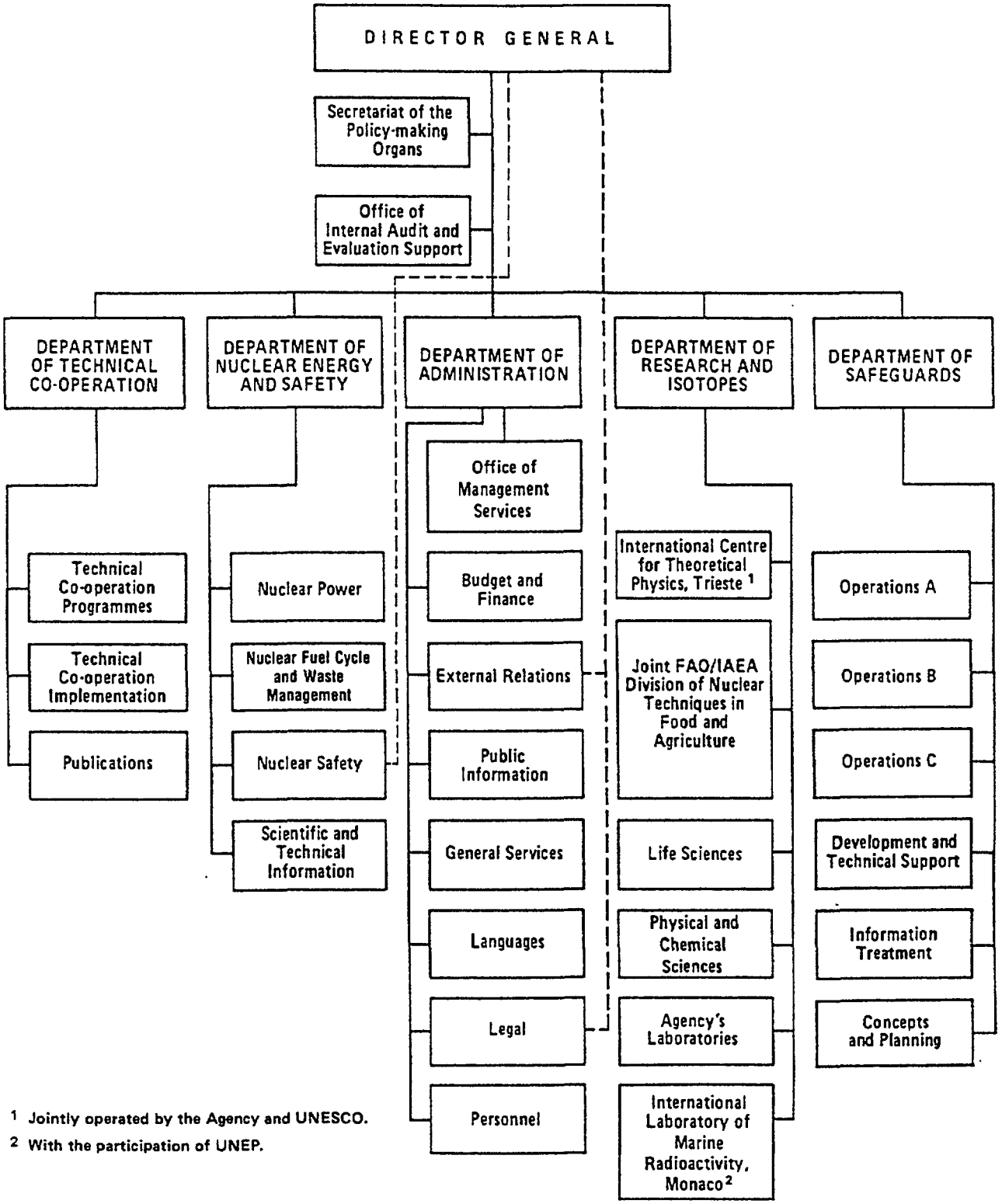
In addition to the publications shown in the tables under the various Areas of Activity and mentioned in the text, 3 books were published in Chinese, 11 in French, 8 in Russian and 11 in Spanish.

Common Printing Service

The Common Printing Service continued to provide document and publication printing services for the Agency and also for UNIDO and the United Nations bodies based at the VIC. In 1989, the income from work for other organizations was similar to that of 1988, i.e. $1.6 million. The output of the Common Printing Service was 204 million page impressions in 1989, compared with 216 million in 1988.

ORGANIZATIONAL CHART

(as of 31 December 1989)



1 Jointly operated by the Agency and UNESCO.

2 With the participation of UNEP.