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**REPORT OF THE INTERNATIONAL ATOMIC ENERGY AGENCY**

Note by the Secretary-General

1. The thirty-third report of the International Atomic Energy Agency for the calendar year 1988 (GC(XXXIII)/873 is submitted herewith to the General Assembly. Major developments since this report was published will be covered by the annual statement of the Director General of the Agency to the General Assembly. This report has been transmitted in accordance with the provisions of article III, paragraph 1 (a), of the Agreement governing the relationship between the United Nations and the International Atomic Energy Agency (General Assembly resolution 1145 (XII), annex).
2. As only a limited number of copies of this report are available, it has not been possible to make a full distribution. Delegations are therefore requested to have the copies transmitted to them available during the discussion of this item.

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\* A/44/150.

# THE ANNUAL REPORT FOR 1988

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GC(XXXII)/873

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INTERNATIONAL ATOMIC ENERGY AGENCY

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# THE ANNUAL REPORT FOR 1988

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## **LIST OF ABBREVIATIONS**

<b>AAS</b>	<b>Atomic absorption spectrometry</b>
<b>ARCAL</b>	<b>Regional Co-operative Arrangements for the Promotion of Nuclear Science and Technology in Latin America</b>
<b>ASTM</b>	<b>American Society for Testing and Materials</b>
<b>CANDU</b>	<b>Canadian deuterium-uranium (reactor)</b>
<b>CEC</b>	<b>Commission of the European Communities</b>
<b>CRP</b>	<b>Co-ordinated research programme</b>
<b>DNA</b>	<b>Deoxyribonucleic acid</b>
<b>ECU</b>	<b>European currency unit</b>
<b>EEC</b>	<b>European Economic Community</b>
<b>ELISA</b>	<b>Enzyme linked immunoabsorbent assay</b>
<b>EURATOM</b>	<b>European Atomic Energy Community</b>
<b>FAO</b>	<b>Food and Agriculture Organization of the United Nations</b>
<b>GATT</b>	<b>General Agreement on Tariffs and Trade</b>
<b>ICP</b>	<b>Inductively coupled plasma</b>
<b>ICTP</b>	<b>International Centre for Theoretical Physics</b>
<b>ILO</b>	<b>International Labour Office</b>
<b>IMO</b>	<b>International Maritime Organization</b>
<b>INTOR</b>	<b>International Tokamak Reactor</b>
<b>ISIS</b>	<b>IAEA Safeguards Information System</b>
<b>ITC</b>	<b>International Trade Centre</b>
<b>LMFBR</b>	<b>Liquid metal cooled fast breeder reactor</b>
<b>NAA</b>	<b>Neutron activation analysis</b>
<b>NDA</b>	<b>Non-destructive assay</b>
<b>NDT</b>	<b>Non-destructive testing</b>
<b>NEA</b>	<b>Nuclear Energy Agency of the OECD</b>

<b>NNW</b>	<b>Non-nuclear-weapon (State)</b>
<b>NPT</b>	<b>Treaty on the Non-Proliferation of Nuclear Weapons</b>
<b>NUSS (programme)</b>	<b>The Agency's programme on nuclear safety standards for nuclear power plants</b>
<b>NW</b>	<b>Nuclear-weapon (State)</b>
<b>NWAL</b>	<b>Network of Analytical Laboratories</b>
<b>OECD</b>	<b>Organisation for Economic Co-operation and Development</b>
<b>PWR</b>	<b>Pressurized water reactor</b>
<b>QA</b>	<b>Quality assurance</b>
<b>QC</b>	<b>Quality control</b>
<b>R&amp;D</b>	<b>Research and development</b>
<b>RCA</b>	<b>Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (INFCIRC/167)</b>
<b>RLA</b>	<b>Regional Latin America</b>
<b>SAL</b>	<b>Safeguards Analytical Laboratory</b>
<b>SDI</b>	<b>Selected dissemination of information</b>
<b>SQ</b>	<b>Significant quantity</b>
<b>TLD</b>	<b>Thermoluminescent dosimeter</b>
<b>UNCTAD</b>	<b>United Nations Conference on Trade and Development</b>
<b>UNDP</b>	<b>United Nations Development Programme</b>
<b>UNEP</b>	<b>United Nations Environment Programme</b>
<b>UNESCO</b>	<b>United Nations Educational, Scientific and Cultural Organization</b>
<b>UNIDO</b>	<b>United Nations Industrial Development Organization</b>
<b>UNSCEAR</b>	<b>United Nations Scientific Committee on the Effects of Atomic Radiation</b>
<b>VIC</b>	<b>Vienna International Centre</b>
<b>WANO</b>	<b>World Association of Nuclear Operators</b>
<b>WASP</b>	<b>Wien Automatic System Planning Package</b>
<b>WHO</b>	<b>World Health Organization</b>
<b>WMO</b>	<b>World Meteorological Organization</b>

**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.**

## Personnel and finance

1. At the end of 1988, the number of members of the Secretariat (including persons serving under Special Service Agreements and on temporary assistance contracts) was 797 in the Professional and higher categories, 1150 in the General Service category and 132 in the Maintenance and Operative Service category.

2. The Regular Budget total for the year 1988 was \$156 182 000 at AS 12.21, of which \$146 838 000 was financed from contributions made by Member States on the basis of the 1988 scale of assessment, \$5 366 000 from income from work for others and \$3 978 000 from other miscellaneous income.

## Main events of 1988

3. The ITER (International Thermonuclear Experimental Reactor) Council held its inaugural meeting (see para. 26); the Board of Governors and the General Conference discussed the extent to which the Agency's programme activities contribute towards achieving the objectives of environmentally sound and sustainable development (see para. 37); the Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention dealing with civil liability for nuclear damage was adopted and opened for signature (see para. 33); the Agency and China concluded an agreement relating to the latter's voluntary offer to place some of its peaceful nuclear installations under Agency safeguards (see para. 31); new premises for the International Laboratory of Marine Radioactivity were officially opened (see para. 30); an international document on food irradiation was adopted by the International Conference on the Acceptance, Control of and Trade in Irradiated Food (see para. 23).

## Nuclear power

4. The total installed nuclear power generating capacity in the world increased by about 4.3% during 1988, reaching 311 GW(e) by the end of the year. Nuclear power plants accounted for about 17% of the world's electricity generation in 1988, at the end of which there were 429 nuclear power plants in operation (see Table 1), representing an accumulated operating experience of around 5000 reactor years.

5. During the year, 14 nuclear power plants came on line (in France, the Federal Republic of Germany, Japan, the Republic of Korea, Spain, the United Kingdom, the USA and the USSR) and construction work started on six plants (in China, France, Japan, the United Kingdom and the USSR). Two reactors with a

total capacity of 335 MW(e) were permanently shut down in the United Kingdom and the USSR. These reactors were first connected to the grid in 1962 and 1964 respectively.

6. The worldwide evolution of nuclear power continued during the year 1988 without significant changes or spectacular events, maintaining in general the same trends that prevailed in 1987. Most Member States with ongoing nuclear power programmes continued according to their respective plans, building up the nuclear contribution to the electricity generation sector. In some Member States, where the opposition to nuclear power is strong, the slow-down or suspension of nuclear power programmes continued, notwithstanding the trend of increasing concern regarding the environmental effects of other sources of electricity.

## Nuclear fuel cycle

7. Particular attention was paid in 1988 to: the long term uranium supply/demand situation; the economics, safety and regulatory aspects of uranium mining; and the application to emergency response situations of the techniques and data developed during uranium exploration. In addition, work was carried out on the safety aspects of the production, handling, storage and transportation of uranium hexafluoride and on the collection and analysis of information on world nuclear fuel cycle facilities. An analysis of the economics of low enriched uranium was performed, and the first "World Atlas of Uranium Occurrences and Deposits", containing over 6000 records of uranium occurrences in 96 countries, was published.

8. In the field of reactor fuel performance, emphasis was placed on improving fuel utilization and the operating conditions at nuclear power plants, with considerable efforts devoted to questions of fuel reliability, safety and quality.

9. As regards the back-end of the nuclear fuel cycle, the main emphasis was placed on the safety, economic, technical and environmental aspects of spent fuel storage and on the strategies and options of spent fuel management as a whole.

## Radioactive waste management

10. During 1988, emphasis on waste management problems of developing countries received high priority. The Waste Management Advisory Programme (WAMAP) conducted missions to 12 developing countries, providing assistance on the establishment and implementation of national radioactive waste management programmes. Programme support was also

**Table 1**  
**Nuclear power reactors in operation and under construction at the end of 1988**

Country name	In operation		Under construction		Electricity supplied by nuclear power reactors in 1988		Total operating experience to end 1988	
	No. of units	Total MW(e)	No. of units	Total MW(e)	TW(e)·h	% of total	Years	Months
Argentina	2	935	1	692	5.1	11.2	20	7
Belgium	7	5 480			40.6	65.5	86	7
Brazil	1	626	1	1 245	0.6	0.3	6	9
Bulgaria	5	2 585	2	1 906	16.0	35.6	43	8
Canada	18	12 185	4	3 524	78.2	16.0	206	0
China			3	2 148				
Cuba			2	816				
Czechoslovakia	8	3 264	8	5 120	21.7	26.7	44	1
Finland	4	2 310			18.4	36.0	39	4
France	55	52 588	9	12 245	260.2	69.9	488	1
German Democratic Republic	5	1 694	6	3 432	10.9*	9.9	72	5
Germany, Federal Republic of	23	21 491	2	1 520	137.8	34.0	279	3
Hungary	4	1 645			12.6	48.9	14	2
India	6	1 154	8	1 760	5.4	3.0	72	8
Iran, Islamic Republic of			2	2 392				
Italy	2	1 120					77	10
Japan	38	28 253	12	10 931	167.8*	23.4	394	0
Korea, Republic of	8	6 270	1	900	38.0	46.9	36	4
Mexico			2	1 308				
Netherlands	2	508			3.5	5.3	35	9
Pakistan	1	125			0.2	0.6	17	3
Poland			2	880				
Romania			5	3 300				
South Africa	2	1 842			10.5	7.3	8	3
Spain	10	7 519			48.3	36.1	82	7
Sweden	12	9 693			66.3	46.9	135	2
Switzerland	5	2 952			21.5	37.4	68	10
Union of Soviet Socialist Republics	56	33 823	26	21 230	215.7	12.6	687	2
United Kingdom	40	11 921	2	1 833	55.5	19.3	810	10
United States of America	108	95 273	7	7 689	526.9	19.5	1261	10
Yugoslavia	1	632			3.9	5.2	7	3
<b>Worldwide<sup>a</sup></b>	<b>429</b>	<b>310 812</b>	<b>105</b>	<b>84 871</b>	<b>1794.9</b>		<b>5040</b>	<b>9</b>

<sup>a</sup> "Worldwide" figures include Taiwan, China, where there were six units with a total capacity of 4924 MW(e) in operation and where a total of 44 years and 1 month of operating experience had been gained.

\* An asterisk indicates estimates.



provided for technical co-operation projects in 19 Member States.

11. Increased importance was placed on the Agency's radioactive waste management programme. The International Radioactive Waste Management Advisory Committee (INWAC) was established to provide advice and guidance.

12. Efforts continued on the preparation of safety standards and guides in various aspects of radioactive waste management. International consensus was achieved in the area of exemption of radiation sources and practices from regulatory control.

## **Nuclear safety and radiation protection**

13. Six Operational Safety Review Team (OSART) missions visited nuclear power plants in six countries, and a report on the generic findings of seven missions over the period 1987-1988 was prepared. The approach developed under the Operational Safety Indicators Programme (OSIP) continued to be used in conjunction with OSART missions. The number of reports on unusual safety related events at nuclear power plants recorded in the Incident Reporting System (IRS) increased from 421 to 613.

14. INSARR (Integrated Safety Assessment of Research Reactors) missions visited five countries, and a comprehensive publication programme began on research reactor safety.

15. Virtually all Member States with ongoing or emerging nuclear power programmes responded to a questionnaire about regulatory standards and practices and possible ways to achieve consistency among national regulatory safety approaches.

16. The International Nuclear Safety Advisory Group (INSAG) completed its pioneering work on developing basic safety principles for nuclear power plants (INSAG-3). In the area of probabilistic safety assessment (PSA), a personal computer software package developed for fault-tree and event-tree analysis was distributed to more than 50 users in Member States. The CRP on the comparison of the cost effectiveness of risk reduction among energy systems was completed.

17. Work continued on the development of guidance relating to basic criteria for radiation protection, occupational and environmental protection, radioactive material transport, emergency planning and preparedness, radiation source control, radiation safety of nuclear fuel related activities, and exposure assessment and handling.

18. Through an IAEA/NEA meeting, an international consensus was achieved on the exemption of radiation sources and practices from regulatory control; the exemption principles were documented in the Safety Series. The exercise of extending radiation protection principles to sources of potential exposure was completed and documented. Work began on a CRP for monitoring and assessing radon exposures in the natural environment. The database for environmental radioactivity measurements in Member States was completed and used to support the work of UNSCEAR and two Agency projects. The Agency's Regulations for the Safe Transport of Radioactive Material were updated, and a programme was started to address the problems of source control and spent source management.

19. As a result of requests, Radiation Protection Advisory Teams (RAPATs) reviewed the infrastructures in twelve countries and recommended long term strategies for assistance and co-operation.

20. With regard to the Agency's obligations under the international conventions on early notification of a nuclear accident and on emergency assistance, procedural manuals were completed for distribution to Member States and other users. Co-operation continued with the WMO on the use of the Global Telecommunication System for rapidly transmitting data to over 160 national contact points. Internally, operational plans and procedures relative to emergency response were completed and fully tested. The Agency, together with Member States, began investigating the need for updating the Agency's recommendations on physical protection of nuclear materials contained in INFCIRC.225/Rev.1 in view of recent developments and advances.

## **Application of nuclear techniques**

21. In the area of food and agriculture, the Agency, through the Joint FAO/IAEA Division, continued to help developing Member States to improve their agriculture and food production through the application of isotopes, ionizing radiation and related techniques, especially biotechnology. The Division's programmes were examined in depth by a panel of six international experts in nuclear techniques in agriculture. Their report recommended a gradual increase in emphasis on the use of nuclear techniques in agricultural biotechnology.

22. Over 200 technical co-operation projects were carried out in 62 developing Member States; also 10 regional and one interregional projects were carried out. The Joint FAO/IAEA Division co-ordinated 32 research programmes involving 390 research contracts and agreements dealing with the use of nuclear and related techniques to solve food production and protection problems.

23. A major International Conference on the Acceptance, Control of and Trade in Irradiated Food was held in Geneva in co-operation with FAO, WHO and ITC-UNCTAD/GATT. Agreement was reached, through a final document adopted at the Conference, on a set of principles for the acceptance of irradiated food in trade under strict control by competent national authorities. The document, although not legally binding, is expected to significantly influence the global development of food irradiation.

24. In the life sciences area, assistance continued to be rendered to Member States – and especially to developing countries – on the application of nuclear techniques in medicine (in vivo and in vitro nuclear medicine), applied radiation biology and radiotherapy, radiation dosimetry, and nutritional and health related environmental studies. Many of these activities were carried out in co-operation with WHO.

25. The Agency continued to promote the exchange of information in the physical and earth sciences and to assist both developing and developed countries with the application of nuclear techniques in experimental physics, analytical and radiation chemistry, non-destructive testing, radiation processing, industrial process control, geology, mining and hydrology.

### International co-operation in fusion research

26. In April 1988, representatives of the world's four major fusion programmes – being conducted in Japan, the Soviet Union, the United States and the European Community – met in Vienna under Agency auspices for the opening meeting of the conceptual design study for an international thermonuclear experimental reactor. The project, referred to as ITER, has the goal of producing a design for the next step tokamak experiment.

### Technical co-operation

27. During 1988, a total of 1009 projects were operational and 88 regional and interregional training courses were held. These activities involved 2023 expert assignments. In addition, 1947 persons received training within the framework of the fellowship programme. A five-year summary of programme delivery is given in the following table.

Item	1984	1985	1986	1987	1988
Number of expert assignments	1530	1846	1930	1808	2023
Number of expert man-months served	1550	1585	1516	1356	1239
Number of expert/lecturer assignments undertaken by Agency staff	378	418	449	407	430
Number of purchase orders processed	2970	3391	3738	3701	3386
Number of fellows in the field	702	615	734	870	682
Number of visiting scientists	123	188	203	160	156
Number of participants in training courses	850	926	972	945	1109

As the average value of each purchase order increased significantly, the lower number of purchase orders in 1988 nevertheless represents an increase in the value of the equipment ordered (from \$16.2 million in 1987 to \$19.9 in 1988).

28. Total resources for technical co-operation activities in 1988 increased by nearly 10% over the previous year to \$45.6 million (1987: \$41.5 million). The implementation rate attained for the programme as a whole was 64.1%; it was 65.0% for that part of the programme financed from the Technical Assistance and Co-operation Fund.

### Seibersdorf Laboratories

29. The Agency's Laboratories at Seibersdorf provided experimental back-up services to the programmes of the Department of Research and Isotopes in food and agriculture, physical and chemical sciences and life sciences, and supported the Department of Technical Co-operation by offering in-service training for individual fellows, organizing training courses and supplying technical officers for technical co-operation projects. Training, research and service activities were performed in such areas as soil fertility, irrigation, crop

mutation, insect and pest control, pesticide analysis and formulation, and animal nutrition, health and reproduction (Agriculture, FAO/IAEA programmes); and analytical chemistry, radiation dosimetry, electronics, instrumentation and isotope hydrology (Physical, Chemical and Life Sciences). In addition, the Laboratories provided analytical services for the Department of Safeguards. The Safeguards Analytical Laboratory (SAL) received 1180 samples of nuclear material, the total time needed to conclude verifications by destructive analysis being reduced by a further 17%

### **International Laboratory of Marine Radioactivity**

30. The International Laboratory of Marine Radioactivity, after twenty-seven years in the Musée Océanographique in Monaco, moved to new modern laboratory facilities placed at the disposal of the Agency by the Government of Monaco. The opening ceremony took place on 12 November 1988.

### **Safeguards**

31. The Agency and China concluded an agreement relating to the latter's voluntary offer to place some of its peaceful nuclear installations under Agency safeguards. When this agreement enters into force, voluntary offer safeguards agreements will be in force between the Agency and the five nuclear-weapon States.

32. In 1988, 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.<sup>1</sup> It is considered reasonable to conclude that the nuclear material under Agency safeguards in 1988 remained in peaceful nuclear activities or was otherwise adequately accounted for. This statement is based on the latest 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.

### **Liability for nuclear damage**

33. On 21 September 1988, the Joint Protocol relating to the Application of the Vienna Convention and the Paris Convention dealing with civil liability for nuclear damage was adopted and opened for signature at the international conference jointly organized by the OECD/NEA and the IAEA.

34. At its thirty-second regular session, the General Conference adopted a resolution on liability for nuclear damage in which it requested the Board of Governors to continue, as a matter of priority, consideration of the question of liability for damage arising from a nuclear accident, and to convene in 1989 an open-ended working group to study all aspects of liability for nuclear damage.

### **Committee on Assurances of Supply**

35. Following the June 1987 session of the Board of Governors, at which the Board took note of the fact that the Committee on Assurances of Supply (CAS) had requested the CAS Bureau to hold further consultations with Committee members about outstanding problems, and especially the problem of completing the formulation of principles of international co-operation in the field of nuclear energy<sup>2</sup>, the Bureau held consultations in March and November 1988. For the purpose of facilitating the discussion on principles, the Secretariat prepared a document on the development of the world nuclear power market since 1980. It was agreed during the November 1988 consultations that the Bureau would hold further consultations in 1989 and report on the outcome to the Board in June 1989.

### **Article VI of the Agency's Statute**

36. At the request of the General Conference, the Board of Governors re-established an informal working group which - in 1987 - had examined proposals on the question of revising Article VI of the Agency's Statute (concerning the Board of Governors). The group's report was transmitted by the Board to the General Conference, which, in September, requested the Board to re-establish the group once again. This the Board did immediately after the 1988 regular session of the Conference.

### **Resolutions adopted by the Agency's General Conference and matters of special interest to the Agency discussed by the General Assembly of the United Nations**

37. In resolution GC(XXXII)/RES/494, on the Agency's contribution to sustainable development, the General Conference requested the Director General "to submit to the Board of Governors in February 1989 information on the contribution of the Agency's programme activities towards achieving the objectives of environmentally sound and sustainable development as a basis for a report to be submitted to the forty-fourth session of the General Assembly".

38. In resolution GC(XXXII)/RES/487, on Israeli nuclear capabilities and threat, the General Conference

1 In the case of voluntary-offer agreements with nuclear-weapon States, nuclear material to which safeguards were being applied was not withdrawn from safeguards except in conformity with these agreements.

2 See, in this connection, paragraph 31 of document GC(XXXII)/835 (The Annual Report for 1987).

requested the Director General: to consider the implementation by the IAEA of provisions in United Nations General Assembly resolutions 41/12, 41/93 and 42/44 in relation to the IAEA; to inform the Secretary-General of any steps Israel may undertake to place its nuclear facilities under Agency safeguards; and to report to the Board of Governors and the next session of the General Conference on Israeli nuclear capabilities and threat and on the implementation of this resolution. The Director General was also requested, "pending the acceptance by Israel to place all its nuclear facilities under IAEA safeguards, to prepare a technical study on different modalities of application of IAEA safeguards in the region, taking into account the Agency's experience in applying its safeguards". It decided to include an item entitled "Israeli nuclear capabilities and threat" in the agenda for the thirty-third regular session of the General Conference.

39. In resolution GC(XXXII)/RES/503, 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 in accordance with Article XIX.B of the Statute, at the thirty-third 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(XXXI)/RES/468 and to report to the thirty-third regular session of the General Conference in this regard". The Conference also decided "to include in the agenda of the thirty-third session of the General Conference an item entitled 'South Africa's nuclear capabilities'".

40. In resolution GC(XXXII)/RES/490, on dumping of nuclear wastes, the General Conference called upon the Agency to ensure that any assistance provided by it or under its auspices shall not in any way allow nuclear waste dumping practices, and to give priority consideration to requests by developing countries for assistance in the field of nuclear waste management. The Director

General was requested to "establish a representative technical working group of experts with the objective of elaborating an internationally agreed code of practice for international transactions involving nuclear wastes based on, inter alia, a review of current national and international laws and regulations on waste disposal".

41. Several matters of interest to the Agency were discussed at the forty-third session of the General Assembly. In the debate that followed the presentation of the Agency's annual report for 1987, 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.

42. The General Assembly adopted the following resolutions which are of direct interest to the Agency: the prohibition of the development, production, stockpiling and use of radiological weapons (A/RES/43/75J); the prohibition of the dumping of radioactive wastes for hostile purposes (A/RES/43/75Q); the dumping of radioactive wastes (A/RES/43/75T); consideration of the Declaration of the 1990s as the Third Disarmament Decade (A/RES/43/78L); the implementation of the conclusions of the Third Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons and the establishment of a Preparatory Committee for the Fourth Review Conference (A/RES/43/82); the establishment of a nuclear-weapon-free zone in the region of the Middle East (A/RES/43/65); Israeli nuclear armament (A/RES/43/80); the implementation of the Declaration [on the Denuclearization of Africa] (A/RES/43/71A), and the nuclear capability of South Africa (A/RES/43/71B); the effects of atomic radiation (A/RES/43/55); and a United Nations conference on environment and development (A/RES/43/196).

# THE AGENCY'S ACTIVITIES

## TECHNICAL CO-OPERATION

### *General issues during 1988*

43. The year under review, 1988, saw the preparation of the first two-year programme, covering the Agency's technical co-operation activities for 1989-90. This meant an increased workload in 1988 but will, in the longer term, yield significant benefits as workloads will be spread more evenly and more time will be available for thorough project formulation and preparation.

44. The provision of preparatory assistance continued during 1988 under the special project approved by the Board for that purpose. In total, 53 missions were planned, of which 50 were carried out. This involved 62 expert assignments to 28 countries for a total of 16 months. Pre-project support in 1988 resulted in the formulation of 33 project proposals which were approved within the framework of the 1989-90 programme.

45. After extensive consultations among Member States, the mandate of the Technical Assistance and Co-operation Committee (TACC) of the Board was clarified at the Board's September 1988 meetings.

46. Data transfer between the Financial Information and Control System (FICS) and the Technical Co-operation Management System (TCMS) improved further, and linkages were established with the Agency's Research Contract Data Base. The Agency's first local area network (LAN), which involves the interconnection of personal computers, was established in the Department of Technical Co-operation.

47. Since its introduction five 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 1988. Evaluation activities continued to provide indispensable insights into the Agency's technical co-operation activities.

48. Mid-project and end-of-project evaluations of 57 projects were conducted in 1988. The areas covered by such evaluations in 1988 included radiation protection, the effectiveness of RAPAT missions and health-related

projects. In addition to project evaluations, the Agency's project reporting system to Member States was reviewed, and a comparative study was made of existing regional co-operative arrangements. A second country programme evaluation was completed.

49. The role of women in development has been receiving increasing attention in the governing bodies of the United Nations system. Accordingly, and in recognition of the contribution women can make to development efforts, the Secretariat has, for a number of years, been monitoring the participation of women in Agency technical co-operation programmes. In 1981, for instance, 17.0% of all fellows were women; the corresponding figure for 1988 was 21.4%. Of the 519 training course participants in 1981, 64 – or 12.3% – were women; in 1988, the figure was 16.1%. Although the percentage of women serving as international experts increased only from 2.2% in 1981 to 6.0% in 1988, the percentage of women serving as training course lecturers rose from 1.7% to 9.0% during the same period. In the Division of Technical Assistance and Co-operation, the share of women serving as Professionals increased from 14.7% in 1981 to 27.1% in 1988.

### *Programme implementation and programme trends*

50. The technical co-operation programme at the beginning of 1988 consisted of 827 active projects. During the year, 29 footnote-a/ projects were made operational and 10 projects were approved under the Reserve Fund. Also, three new projects funded by UNDP, two funds-in-trust projects and one special programme project were added to the programme, so that 1009 projects were operational during 1988. Of this total, 161 projects were completed and two were cancelled.

51. The provision of technical assistance in 1988 involved arranging for 2023 expert assignments, processing 3386 purchase orders for equipment and supplies, devising training programmes for 838 fellows and visiting scientists, and organizing 88 regional and interregional training courses for 1109 participants, in addition to furnishing general logistic and administrative support.

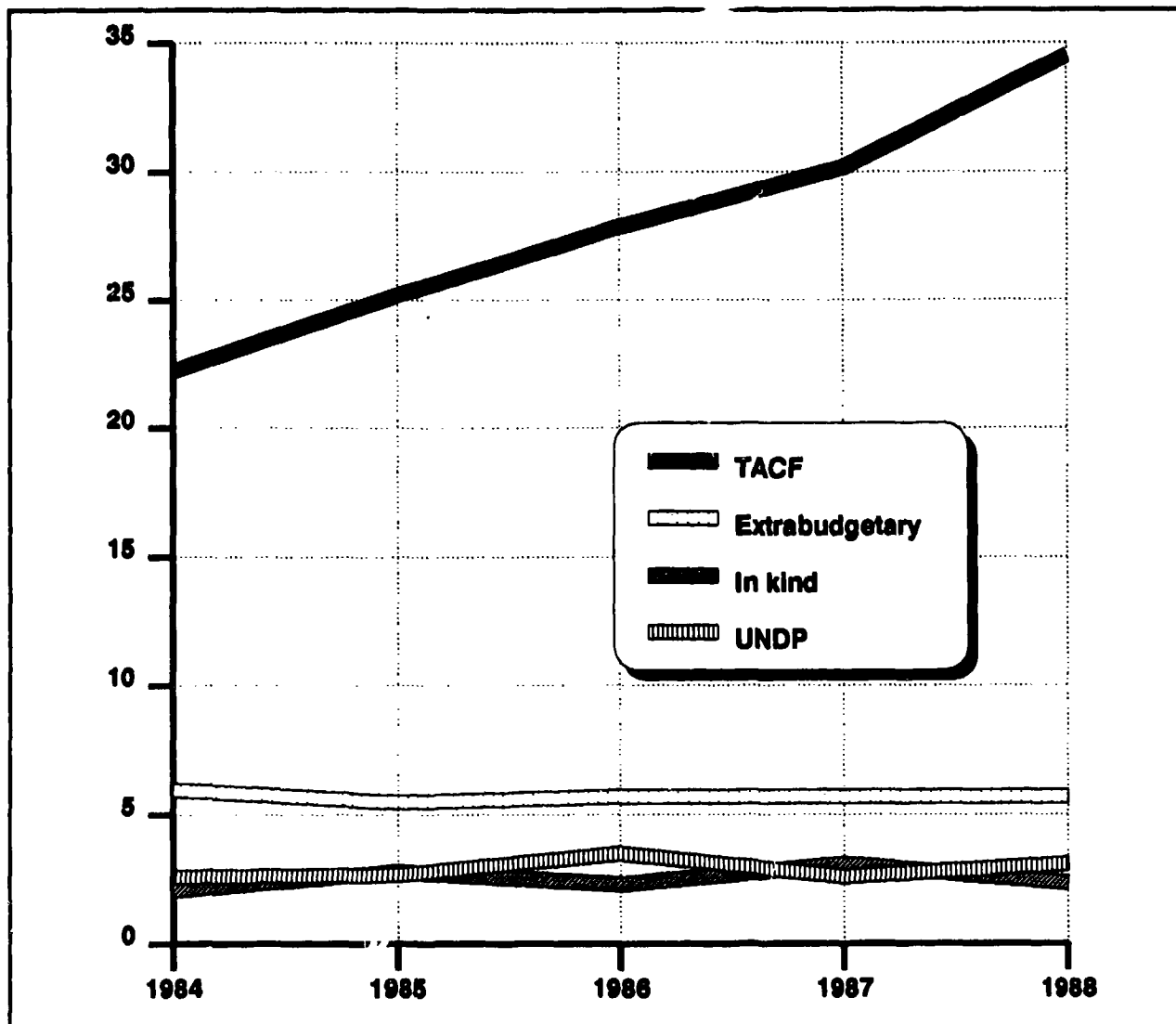
52. Of the assistance delivered in 1988, the largest portion (20%) related to the application of isotopes and radiation in agriculture; projects in this field focused on optimizing fertilizer and water use, animal parasitology, enhancing biological nitrogen fixation, mutation breeding, increasing livestock production, food irradiation and pesticide



Region	Overall share in %				
	1984	1985	1986	1987	1988
Africa	25.5	20.9	19.9	18.5	21.1
Asia & Pacific	26.7	28.4	26.8	30.0	29.0
Europe	11.5	13.1	13.6	18.9	13.9
Latin America	24.7	22.7	22.5	20.3	23.0
Middle East	0.9	1.6	3.1	2.1	3.0
Interregional	10.7	13.4	13.9	9.9	10.0

62. The relative shares of Africa, Latin America and the Middle East increased last year as compared with 1987, while those of Asia and the Pacific and Europe declined somewhat. Interregional's share changed negligibly. 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 1988 as approved by the Board, the regional distribution was as follows: Africa 25.0%, Asia and the Pacific 27.0%, Europe 18.7%, Latin America 22.1%, the Middle East 3.8% and Interregional 3.4%.

**FIGURE 1**  
**RESOURCES AVAILABLE FOR AGENCY**  
**TECHNICAL CO-OPERATION PROGRAMMES: 1984 - 1988**  
(In millions of dollars)



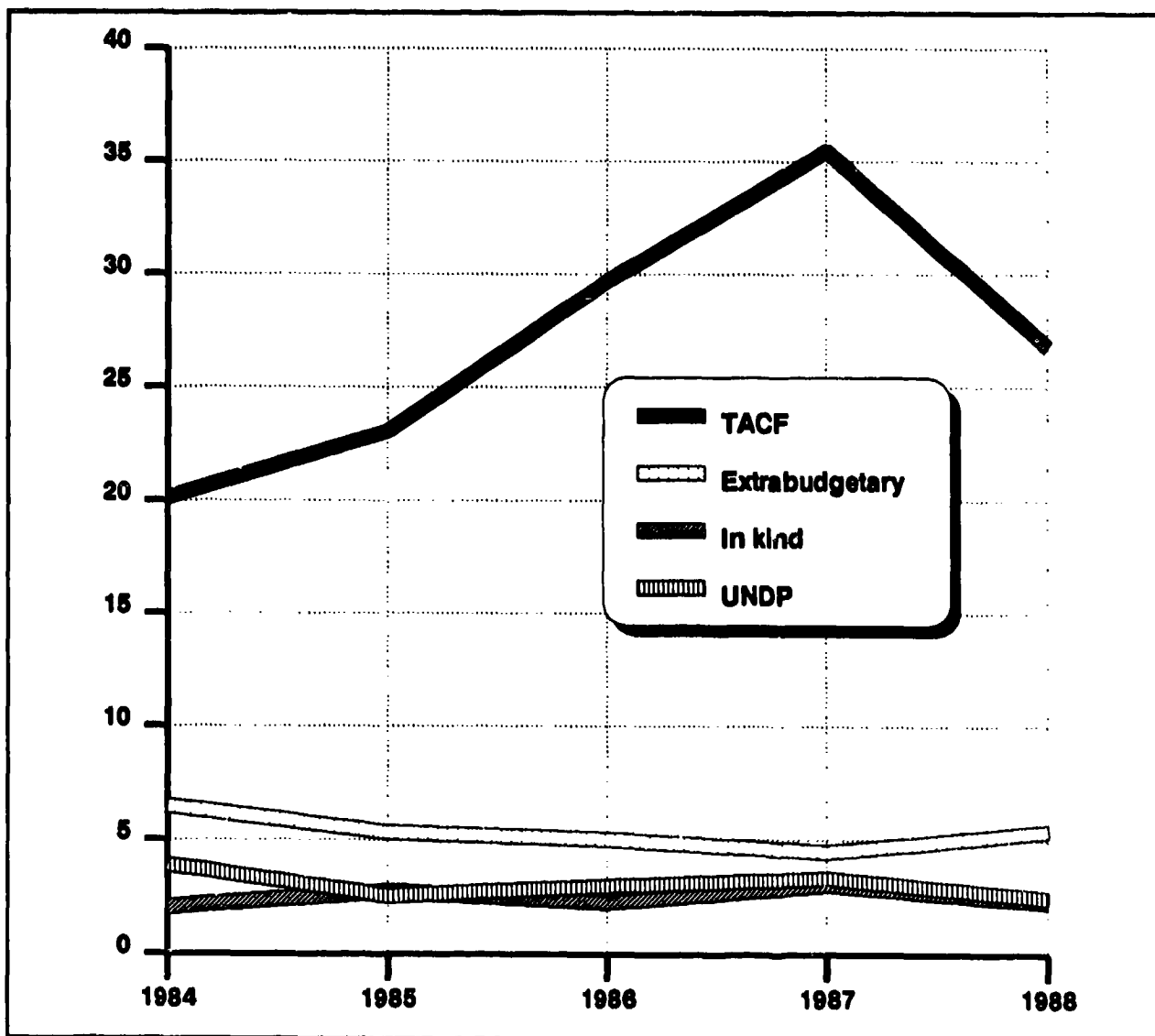
<b>TACF</b>	<b>22.232</b>	<b>25.197</b>	<b>27.860</b>	<b>30.153</b>	<b>34.510</b>
<b>Extra-budgetary funds</b>	<b>5.984</b>	<b>5.484</b>	<b>5.702</b>	<b>5.700</b>	<b>5.713</b>
<b>Assistance in kind</b>	<b>2.066</b>	<b>2.765</b>	<b>2.282</b>	<b>3.066</b>	<b>2.322</b>
<b>UNDP</b>	<b>2.541</b>	<b>2.684</b>	<b>3.480</b>	<b>2.568</b>	<b>3.051</b>
<b>TOTAL</b>	<b>32.803</b>	<b>36.100</b>	<b>39.324</b>	<b>41.487</b>	<b>45.596</b>



**FIGURE 2**

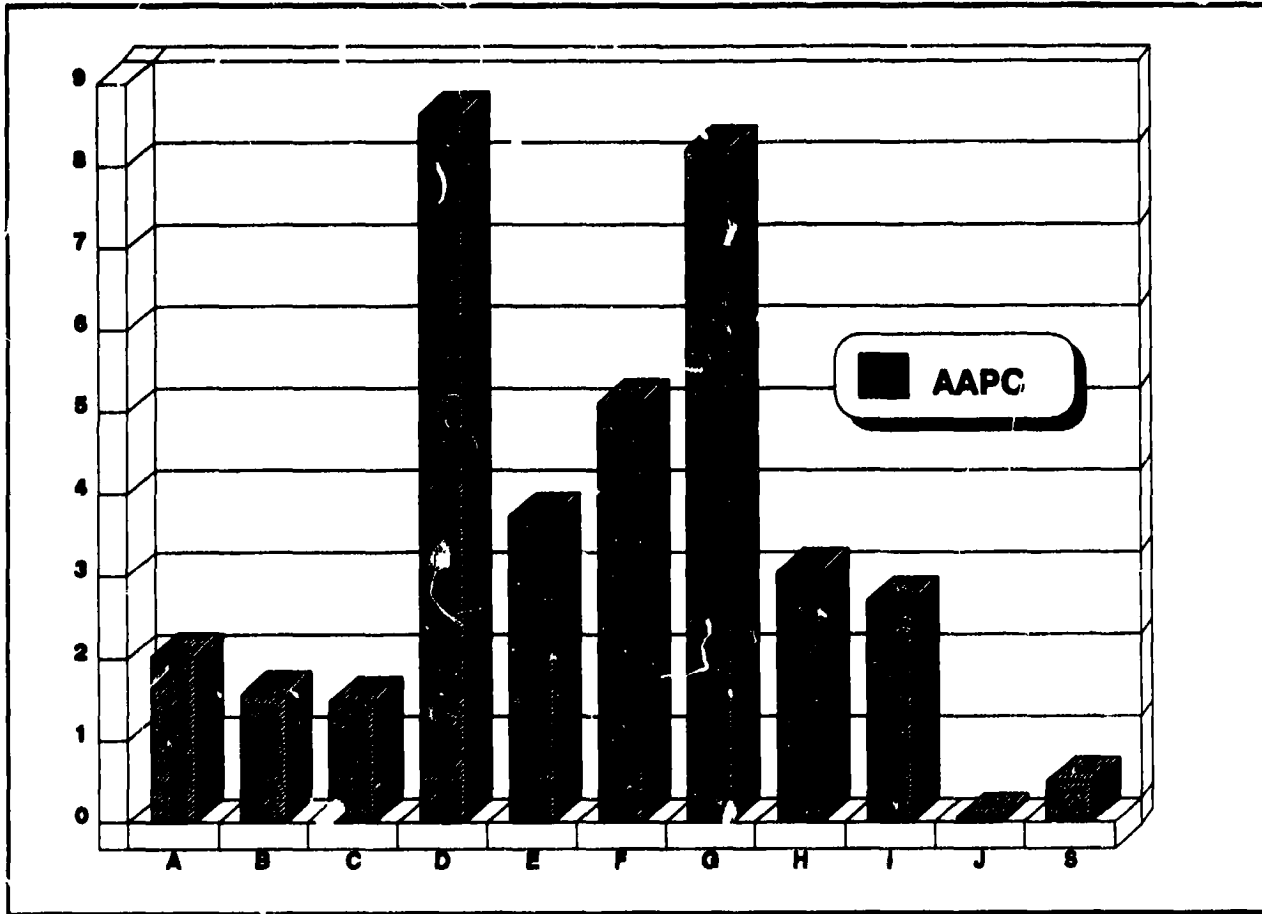
**TECHNICAL CO-OPERATION DISBURSEMENTS: 1984 - 1988**

(In millions of dollars)



<b>TACF</b>	<b>20.124</b>	<b>23.062</b>	<b>29.683</b>	<b>35.460</b>	<b>26.810</b>
<b>Extra-budgetary funds</b>	<b>6.493</b>	<b>5.326</b>	<b>5.025</b>	<b>4.487</b>	<b>5.387</b>
<b>Assistance in kind</b>	<b>2.066</b>	<b>2.765</b>	<b>2.282</b>	<b>3.066</b>	<b>2.323</b>
<b>UNDP</b>	<b>3.899</b>	<b>2.563</b>	<b>2.990</b>	<b>3.332</b>	<b>2.466</b>
<b>TOTAL</b>	<b>32.582</b>	<b>33.716</b>	<b>39.980</b>	<b>46.345</b>	<b>36.986</b>

**FIGURE 3**  
**TECHNICAL CO-OPERATION DISBURSEMENTS BY AAPC: 1988**  
(In millions of dollars)



Code	Area of Activity	Disbursed (\$)	Percentage of total
A	Nuclear Power	2.027	5.48
B	Nuclear Fuel Cycle	1.554	4.20
C	Radioactive Waste Management	1.480	4.00
D	Food and Agriculture	8.621	23.31
E	Human Health	3.719	10.05
F	Industry and Earth Sciences	5.109	13.81
G	Physical and Chemical Sciences	8.195	22.16
H	Radiation Protection	3.042	8.23
I	Safety of Nuclear Installations	2.693	7.28
J	Safeguards	0.060	0.16
S	Direction and Support (including Technical Co-operation Servicing, INIS and Data Processing Services)	0.486	1.13
<b>Total</b>		<b>38.986</b>	<b>100.0</b>

# NUCLEAR POWER

## Nuclear power planning and implementation for developing countries

### (a) Planning tools and methodologies

63. The Agency co-operated in a World Bank/UNDP energy planning project for a number of European and Arab countries, in particular through the transfer of Agency planning tools and methodologies and the provision of training on the use of the methodologies. In this context, the MAED<sup>3</sup> model was transferred to Egypt and Yugoslavia; the VALORAGUA<sup>4</sup> model was transferred to Morocco, Turkey and Yugoslavia; and these countries were assisted in applying the models to national energy, electricity and nuclear power planning studies. The Agency participated in a general review seminar on the project, organized by the World Bank in Tunisia during December.

64. The TUV<sup>5</sup> model was transferred to Yugoslavia, and a team of national energy planners was trained and assisted in using the model to analyse energy demand and supply options for the country.

65. In co-operation with the Nuclear Energy Agency of the OECD, the Agency's TUV model was used to carry out long term projections of global energy and electricity demand. These projections provided a general context for studies of various scenarios of nuclear power growth in the long term (up to the year 2025).

66. Testing and development of the ENPEP<sup>6</sup> package continued during 1988, and this package is expected to become a major Agency planning tool to assist developing Member States in the economic planning of nuclear power programmes. The MAED model was adapted by the Agency for operation on microcomputers and in-

tegrated into the ENPEP package by the Argonne National Laboratory, USA.

67. Work was initiated on defining methodological approaches for incorporating environmental impacts and control costs into the economic analysis of alternative energy sources for electricity generation. The IM-FACTS module of the ENPEP package is being taken as a starting point for this work, which will provide a more complete analysis of the total costs (economic and environmental) of alternative energy sources, in particular for the comparison of nuclear and fossil-fired electricity generation options.

### (b) Promotion and financing of nuclear power in developing countries

68. The problems and possibilities for financing nuclear power programmes in developing countries were the topic of an advisory group which met in June. Following the recommendations of this group, work was begun on a reference book to provide information on experience with conventional and innovative (e.g. build-operate-transfer) approaches to nuclear power financing in developing countries.

69. An Agency team presented a seminar to World Bank staff on various nuclear power topics, including: technical and economic performance, safety and environmental effects, waste management and decommissioning. The purpose was to give the World Bank staff a better appreciation of the characteristics of nuclear energy in comparison with alternative energy sources for electricity generation.

70. A number of discussions between Agency and World Bank staff were organized in Vienna and Washington, related to the electricity and nuclear power programmes of particular developing countries. These

3 MAED: Model for Analysis of Energy Demand.

4 VALORAGUA is a power system simulation model, developed by Electricidade de Portugal (EDP) and made available to the Agency, for carrying out detailed analyses of power systems with a large hydroelectric component.

5 TUV: An energy demand and supply analysis model developed by the Technical University of Vienna (TUV) under contract to the Agency.

6 ENPEP: Energy and Power Evaluation Program, developed by Argonne National Laboratory (USA) supported by the Government of the United States.

discussions were seen as very useful in giving the World Bank a better understanding of the Agency's programme to assist developing countries in the effective and safe implementation of nuclear power.

*(c) Assistance in the planning and implementation of nuclear power programmes*

71. An advisory group reviewed the Agency's various activities to assist developing countries in nuclear power programme planning, in the light of the recommendations made in the Senior Expert Group Report<sup>7</sup> that these individual activities be organized to provide an integrated package approach to the comprehensive planning of nuclear power programmes. The advisory group endorsed this general recommendation and made specific recommendations regarding the scope and organization of the integrated package approach, which will be tested during 1989.

72. The Agency provided technical support in connection with energy, electricity and nuclear power planning studies in Egypt, Indonesia, Malaysia, Thailand, Tunisia, Turkey, Viet Nam and Yugoslavia.

73. Co-operation between the Agency and the World Bank in the planning of energy and electric power systems in developing countries continued. In the context of the World Bank/UNDP energy planning project (see para. 63 above), joint activities were undertaken in Egypt, Morocco, Turkey and Yugoslavia.

74. The Agency provided technical support in connection with feasibility studies and infrastructure development planning projects in China, Malaysia, Morocco and Tunisia.

75. With the overall objective of assisting developing Member States to strengthen their project execution capabilities, support was provided to technical co-operation projects in eight countries. Also, large multi-year, UNDP financed projects in the area of manpower development for nuclear power were supported in Argentina and China.

76. Technical Reports Series guidebooks were published on "Nuclear Power Project Management" (No. 279), and "Developing Industrial Infrastructures to Support a Programme of Nuclear Power" (No. 281). A guidebook on "Education and Training of Technicians for Nuclear Power" was completed for publication.

*(d) Nuclear power training programmes*

77. The Agency participated in a training course on the ENPEP model, organized by the World Bank in the context of the World Bank/UNDP project (see para. 63 above). Twenty participants from nine countries took part in the course.

78. An interregional training course on electricity demand forecasting for nuclear power planning was held at the Argonne National Laboratory, USA; it was the third time that this course was offered by the Agency. It was attended by 30 participants from 10 developing countries. A reference book "Energy and Electricity Demand Forecasting for Nuclear Power Planning in Developing Countries", IAEA-TECDOC-470, was published as a textbook for this course.

79. Three national training courses were held on the commissioning of nuclear power plants, and a national training seminar on load-following technology. In addition, seven two-week national workshops were held on different aspects of nuclear power plant construction, commissioning, operation and maintenance. These training events were in China, the Republic of Korea and Romania.

80. Two interregional training courses (on the qualification of nuclear power plant operations personnel and on water chemistry in nuclear power plants) were held at the Karlsruhe Nuclear Research Centre, Federal Republic of Germany.

81. In the field of quality assurance, six national training courses and seminars were held on the siting, design, construction, commissioning and operation of nuclear power plants (in China, Morocco and Poland).

82. To promote the achievement of high standards in nuclear power plant operations, a guidebook was completed on "Training to Establish and Maintain the Qualifications and Competence of Nuclear Power Plant Operations Personnel". This document updates and complements the guidebook on "Qualification of Nuclear Power Plant Operations Personnel" that was published in 1984, and includes the subject area of continuing education.

7 "Promotion and Financing of Nuclear Power Programmes in Developing Countries". report to the IAEA by a Senior Expert Group (1987).

*(e) Regional co-operation*

83. Within the framework of RCA, the Agency held a regional workshop on electric power planning in Kuala Lumpur, Malaysia. A report on the 1987 workshop held in Jakarta, Indonesia, was published under the title, "Experience with WASP among IAEA Member States Participating in the Regional Co-operative Agreement (RCA) in Asia and the Pacific Region" (IAEA-TEC-DOC-474).

84. A regional training course was held in the Republic of Korea on nuclear power project planning and implementation.

## **Performance of nuclear power**

*(a) The Agency's power reactor information system (PRIS)*

85. At the end of 1988, PRIS – to which all but one Member State with power reactors report – contained data for a total of about 3800 years of power reactor operation and on about 27 700 outages. During the year, data sets were supplied on request to contributing Member States and detailed background information was provided for Operational Safety Review Team (OSART) missions. The frequency of requests for PRIS data continued to increase.

86. Using PRIS data, the Agency published editions of "Nuclear Power Reactors in the World" and "Operating Experience with Power Reactors in Member States (1987)". For the first time, this last annual report was published before the General Conference; also for the first time, the report included operating experience data of nuclear power plants in the USSR.

87. PRIS data were extensively used in preparing an IAEA technical document on operational reasons for good nuclear power plant performance.

88. After completing all preparations in co-operation with NESI, on-line access to PRIS was offered to the Agency's Member States. The preparations included a pilot project with the Nuclear Information Center, Prague, Czechoslovakia, which provided valuable information and experience in establishing on-line connection, as well as in identifying and solving problems. Also, a full set of documents (PRIS Overview, Reference

Manual, Access Manual, Training Course Outline) were developed. PRIS on-line access was offered to WANO on a trial basis.

*(b) Performance status and trends*

89. 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 electric power plants, with the Agency contributing data on nuclear power plants.

90. Nuclear power plant availability continued to show improvements. The worldwide average energy availability of nuclear power plants in 1987 was 71.4% (70.5% in 1986); the proportion of plants with high availability also increased (see Fig. 4).

91. Work on identifying the reasons for outstanding performance records proceeded during the year 1988, and a technical document was completed on "Operational Reasons for Good Nuclear Power Plant Performance", which is intended as an aid for operating organizations to enhance plant performance.

*(c) Quality management*

92. Within the framework of the revision of the Agency's five NUSS Codes of Practice, a revised version of the Code on Quality Assurance (Safety Series No. 50-C-QA (Rev. 1)) was published.

93. A "Manual on Quality Assurance for Computer Software related to the Safety of Nuclear Power Plants" was published in the Technical Reports Series (No. 282).

94. Work was completed on manuals on quality assurance for installation and commissioning of instrumentation, control and electrical equipment in nuclear power plants and on quality management for nuclear power plant operation. Development of a manual on corrective actions reached an advanced stage and a first draft of a manual on measuring effectiveness of quality management systems was prepared.

## **Nuclear power technologies**

*(a) Evolution of current technologies*

95. An Agency conference was held in Tokyo on the Man-Machine Interface in the Nuclear Industry (Control and Instrumentation, Robotics and Artificial Intel-

ligence) in co-operation with CEC and OECD/NEA. It was attended by about 460 participants from 28 Member States and 4 organizations, and it assessed the problem of the man-machine interface from various aspects of plant design, computer application, training, robotics, etc., aiming at the improvement of the safety and reliability of nuclear power generation.

96. Two specialists meetings were held under the auspices of the International Working Group on Nuclear Power Plant Control and Instrumentation. The first, on microprocessors in systems important to the safety of nuclear power plants, showed that the advantages of the use of microprocessors in systems important to safety continue to be more widely recognized but that some problems remain with validation and verification of software for these systems. At the second meeting, on man-machine communication for emergency operation in nuclear power plants, it was found that additional instrumentation may be needed for some plants to fully meet emergency operating procedures. Areas where such additional instrumentation may be needed were identified.

97. Work continued on a report on the design of control rooms and the man-machine interface for the operation and surveillance of nuclear power plants, summarizing the steps which have been taken and are being planned worldwide to improve the man-machine interface.

98. The CRP on modelling approaches for nuclear power plant simulators was concluded after four years of work. A final report will be published soon.

99. A meeting was held on the CRP on optimizing reactor pressure vessel surveillance programmes and their analysis (Phase III). The participants reported some first results on testing both irradiated and unirradiated materials. One of the outcomes of the meeting was a proposal to establish on a contract basis a data acquisition bank for the test results obtained on the CRP pressure vessel steels.

100. A meeting of the International Working Group (IWG) on the Reliability of Reactor Pressure Components was held. The participants considered national research and development work in the area of pressure boundary components, overviewed the IWG activities since the previous meeting and elaborated proposals for future activities, giving strong support to the Agency's programme on ageing and life extension of nuclear power plants.

101. A specialists meeting was held on the inspection of austenitic dissimilar materials and welds; this resulted in a very significant improvement in the understanding and interpretation of different techniques for ultrasonic

testing of austenitic materials, dissimilar materials and welds.

102. The specialists meeting on fracture mechanics verification by large scale testing addressed problems related to verification of fracture toughness testing results obtained from small specimens by large scale specimens, or in some cases full scale tests of pressure vessels/components. Some unique results were presented regarding tests conducted on big testing machines.

103. The specialists meeting on corrosion and erosion aspects of pressure boundary components summarized the body of knowledge of the corrosion/erosion problem, which is now well understood and for which technological solutions are available. The role of operating and economic constraints in the implementation of these solutions was emphasized and it was recommended that each utility should review the problems of corrosion/erosion on a continuing basis.

104. The International Working Group on Advanced Technologies for Water Cooled Reactors (IWGATWR) had its second meeting. It reviewed and discussed trends in national programmes, accorded a high priority to improvements in the current generation of water cooled reactors, and recommended that Agency's activities for 1989 and 1990 should focus on technology areas related to passive safety and cost reduction.

105. Within this framework, two technical meetings were convened: on the definition and understanding of engineered safety, passive safety and related terms, and on progress in heavy water reactor design and technology.

106. An important status report on advanced LWR design and technology was published. A similar document on advanced HWR designs was started and is due to be published in 1989.

107. Within the framework of reactor core related activities that the Agency has reactivated, a technical committee was held to review the current status of core calculation tools and the needs of Member States to establish or update their in-core fuel management capability.

108. To encourage R&D and facilitate exchanges of experience in safety related technology and design areas, CRPs were initiated on: in-core fuel management codes in LWRs with a possible extension to HWRs, and the use of burnable poisons in WWERs. In addition, the establishment of an LWR thermal database was initiated on the recommendation of the IWGATWR.

# Reactors with High Energy Availability Factor

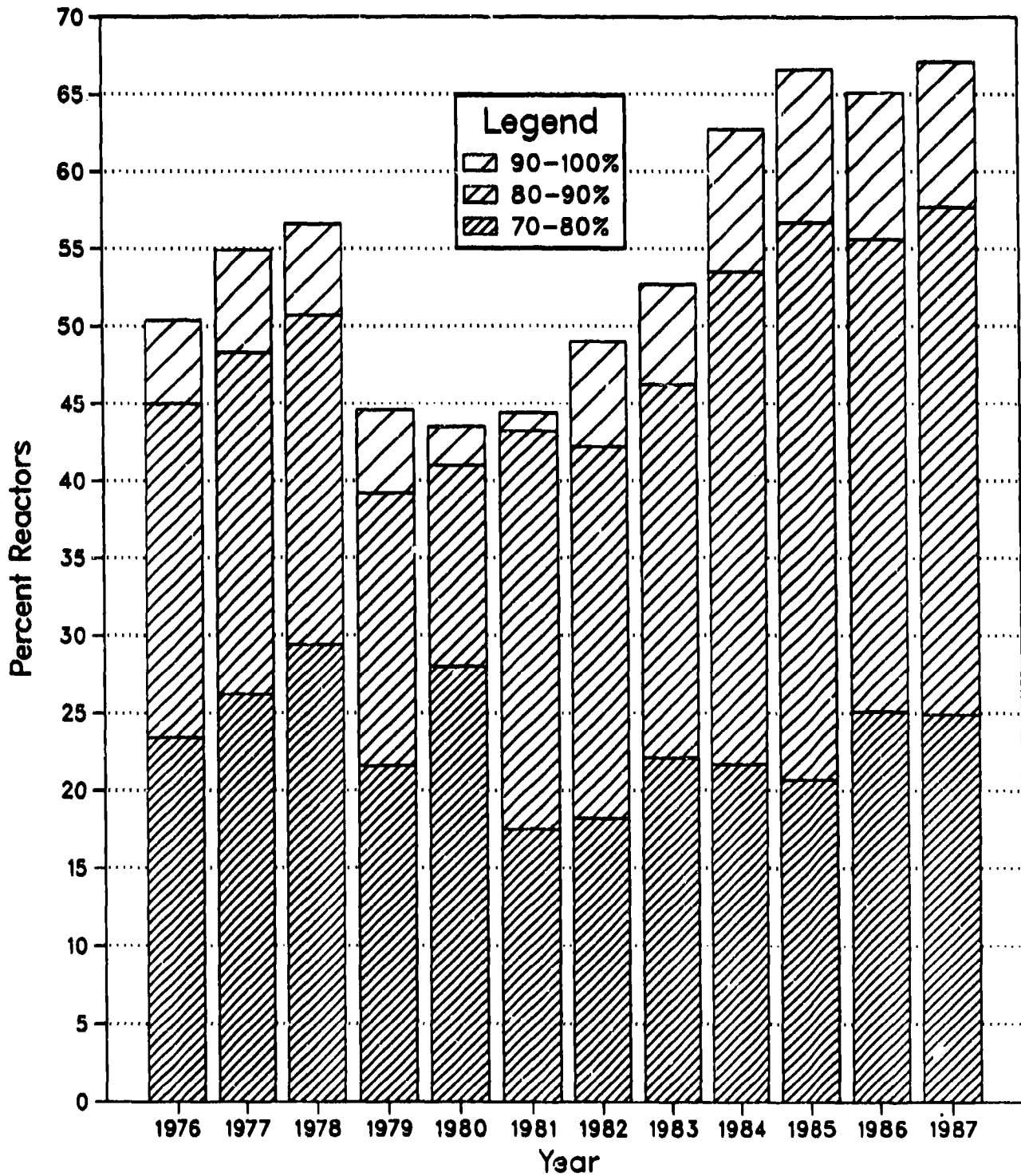


FIG. 4.

109. Selection criteria and specific design requirements for future application of advanced concepts in developing countries were reviewed and discussed in two technical committees. Emphasis was given to small sized co-generation plants. A document will be published in 1989.

*(b) Technologies for better resource utilization*

110. At its 21st Annual Meeting, the International Working Group on Fast Reactors (IWGFR) reviewed current trends in national development programmes. The view was reaffirmed that fast breeder reactors still remain the only practical means for the foreseeable future of utilizing the uranium resources as effectively as possible. The international co-operation established in recent years in this field is progressing.

111. Specialists meetings were organized on sodium fires and on methods for control rod calculations in fast reactors. Both topics, selected by the IWGFR, are considered important for the safe and reliable operation of fast reactors.

112. Good results were achieved in the last stage of the CRP on signal processing techniques for sodium boiling noise detection, whose review report will be published in 1989. Recommendations were made for an extension of the CRP.

113. The CRP on intercomparison of LMFBR core mechanics codes has nearly completed the verification phase. Preparation of the validation exercise (code against experiment) has started.

*(c) Nuclear heat applications*

114. A specialists meeting reviewed the state-of-the-art of high temperature metallic materials for gas cooled reactors and identified directions for future R&D programmes.

115. Gas cooled design requirements, operational experience and maintenance were discussed during a technical committee.

116. The final results of the CRP on design codes for components of gas cooled reactors were reviewed by the participants. Preparation of a report on the programme was started.

*(d) Nuclear fusion*

117. A review was made of the status of robotics and remote maintenance concepts for future machines.



# NUCLEAR FUEL CYCLE AND RADIOACTIVE WASTE MANAGEMENT

## Nuclear materials and fuel cycle technology

118. Sixty-five Member States were involved in Agency fuel cycle technology activities in 1988. A number of basic new and important projects were successfully started, including the international study on water reactor extended burnup, the project on post-accident management of severely damaged nuclear fuel and radioactive waste arising; and the study on safety aspects of production, handling, transport and storage of uranium hexafluoride. A comprehensive internal analysis was completed on the status and trends in the world nuclear fuel cycle and on the methodology of work performed by the Agency with emphasis on expected changes and corresponding probable directions for international co-operation. The results of analytical reviews were published in Agency books, in proceedings of outside meetings and in a number of national and international journals. Seventeen comprehensive Agency reports were published in 1988 on subjects extending from uranium exploration to spent fuel management. Technical assistance in this broad area was provided to 33 Member States.

### *(a) Nuclear raw material resources*

119. The near term outlook in WOCA for uranium continues to be influenced by oversupply and low prices. With reactor related uranium requirements of about 37 600 t and 38 600 t U in 1987 and 1988 respectively, the uranium production remained below requirements. Large inventories, estimated at three to four years of forward requirements, filled this gap and are expected to do so for a number of years.

120. WOCA's uranium production in 1987 totalled 36 790 t U. The main producers continued to be Australia, Canada, South Africa and the United States of America. The 1988 production is expected to be about 36 000 t U.

121. In 1987, the latest year for which reliable figures are available, average uranium contract prices developed differently in WOCA's various geographical regions, reflecting the erratic behaviour of some exchange rates.

122. In Australia, the average export price remained stable in local currency, but increased from about \$53 to about \$57/kg U. The Canadian average price paid for deliveries under export contracts decreased further by about \$5 to \$59.60/kg U. In the EEC area, prices paid

increased by about \$4 to \$84.50/kg U, but decreased from ECU 81.90 to ECU 73.45/kg U. The average US price for domestic uranium further declined by about \$7 to \$71.16/kg U, while prices for imported material increased from \$52.20 to \$54.50/kg U. Spot prices for non-US uranium in 1988 declined to less than \$40/kg U, while those for US material during the first four months were slightly higher at \$41/kg U.

123. As a consequence of low uranium prices, exploration in WOCA in 1987 and 1988 was at a slightly lower level of \$125-140 million per annum. While the largest share is expended in Canada, France and the USA, many developing countries in Asia and the Middle East continue their exploration efforts. About 50% of the exploration expenditures are funded by consumer countries such as France, the Federal Republic of Germany, Japan, the Republic of Korea, Switzerland and the United Kingdom.

124. A total of seven Agency reports were issued during the year. Two proceedings on "Uranium Deposits in Asia and the Pacific: Geology and Exploration" and "Recognition of Uranium Provinces" were published. A Technical Report on "Geochemical Exploration for Uranium" was also issued. Four technical documents (IAEA-TECDOCs) on the following topics were distributed: "Contractual Arrangements for Uranium Exploration and Mining"; "Geological Data Integration Techniques"; "User's Guide for Uranium Ore Reserve Calculation (URAD)"; and "INTURGEO: The International Uranium Geology Information System (A World Atlas of Uranium Occurrences and Deposits)" (IAEA-TECDOCs Nos 468, 472, 471 and 484). The last document is the only one of its kind and contains over 6000 records of uranium occurrences and deposits in 96 countries. Manuscripts on "Uranium Resources and Geology of North America" and "Technological Aspects of Uranium Mining" were submitted for publication.

125. The second issue of the Uranium Newsletter was published in June. This issue, 43 pages in length, contains reports from 23 countries, 5 more than the first issue. The mailing list has grown to include over 800 names, and additional requests are continuing to be received.

126. A consultants meeting was held to continue work on a Technical Reports Series document on the use of regional gamma ray data to define the natural radiation environment. It is expected that the document will be submitted for publication early in 1989.

127. A consultants meeting was held to begin preparation of a Technical Reports Series document on airborne gamma ray spectrometry. This report will be a state-of-the-art guide to the latest airborne gamma ray spectrometer techniques for use in uranium exploration, geological mapping, mapping of background

radiation exposure rates and emergency response situations. The report will be completed in 1990.

128. A consultants meeting was held on uranium deposit classification and recognition criteria to propose a classification scheme which will accommodate newly discovered deposits. It is expected that the new classification will provide a unified standard to workers in this field for at least the next decade.

129. Consultants meetings on long term uranium supply and on resource appraisal were held. A manual on undiscovered resource assessment is being drafted.

130. An advisory group meeting on uranium resources, exploration and production was held to review the Agency's uranium activities.

131. An advisory group meeting on uranium exploration planning and practice was held in December. The papers and discussion will be compiled into an IAEA-TECDOC and made available to senior government planners and decision makers to assist them in establishing the conditions and mechanisms for encouraging uranium development in their countries.

132. Thirty-three technical co-operation projects on uranium exploration and resource development in 31 countries were supported. More and more countries are seeking the Agency's assistance on the use of uranium exploration data and techniques for the assessment of other mineral resources and the preparation of baseline information for natural background radiation and other environmental monitoring. This level of support is about the same as in the previous year.

*(b) Processing of nuclear and reactor materials*

133. In co-ordination with the World Nuclear Fuel Market, a technical committee meeting on the economics of low enriched uranium was held with the participation of experts from 40 Member States. Various aspects of the uranium market, conversion, enrichment, recycling of uranium and plutonium were reported on and discussed in depth. The proceedings of the meeting will be published as an IAEA-TECDOC.

134. The first consultants meeting on the safe production, handling, transportation and storage of uranium hexafluoride was held in November. Elaboration of a guidebook on the subject was started with the participation of experts from five leading countries and one international organization.

135. Work continued on the preparation of a guidebook on the design, construction and operation of pilot plants and the document was submitted for publication. A guidebook on the development of projects for the

production of uranium concentrates will be finalized in March 1989.

136. Two consultants meetings were held to start work on the preparation of the second edition of a monograph on uranium extraction technology and of a guidebook on the economic evaluation of uranium production projects.

137. Three reports were completed for issue in early 1989. These are the second edition of the "Nuclear Fuel Cycle Information System", "Recovery of Uranium from Phosphoric Acid" (IAEA-TECDOC) and "Manual of Analytical Techniques in Uranium Exploration and Ore Processing" (Technical Reports Series).

*(c) Reactor fuel design, fabrication and performance*

138. The Agency's programme in the subject area continued to cover experience in operating water cooled nuclear power plants with uranium oxide fuel and existing schemes of fuel utilization, and improvements in reactor fuel design, performance and reliability. The programme includes consideration of high burnup fuel performance, advanced fuel management, QA and QC in fuel fabrication, nuclear material investigation, post-irradiation examination techniques, water chemistry, as well as new directions: the industrial use of the mixed oxide (MOX) technology and an assessment of the economics of high burnup operation - in particular, the impact of advanced fuel utilization on fuel cycle costs. All these aspects are now under extensive consideration in IAEA Member States with developed programmes and represent also matters of great interest for developing countries.

139. The International Working Group on Water Reactor Fuel Performance and Technology (IWGFPT) held its intermediate meeting in September and confirmed the recommendations of the VIIIth Plenary Meeting in 1987. Emphasis was given to fuel reliability and performance for high burnup, fuel management and economics and improvements of procedures for technical assistance.

140. Guidebooks on "Quality Assurance in Fuel Fabrication" and on "Quality Control for Gadolinium Bearing and Mixed Oxide Fuels" have been completed and submitted for publication.

141. A technical committee meeting on burnup determination of water reactor fuel was held. Participants discussed the state-of-the-art of the following aspects of burnup determination: destructive analysis, methodology and experience and calculation models and their qualification. Recommendations on future R&D include the following topics: the conversion from "atompercent burnup" to energy produced determina-

tion of the radial burnup, experiments on spent fuel (Gd-absorber and MOX) to verify codes and fuel performance, burnup analysis of highly burnt UO<sub>2</sub> and MOX fuel, NDA burnup determination, and the accuracy of nuclear data related to neutron emission from spent fuel.

142. A technical committee meeting on water reactor fuel element computer modelling in steady state, transient and accident conditions was held. This meeting was the fifth in a series. Topics raising most interest in the meeting were transient fission gas release, axial gas mixing, degradation of UO<sub>2</sub> thermal conductivity, enhancement of gas diffusion coefficients and chemistry effects. The data from recent investigations show burst and spike release at power transients, a ramp rate effect and significant releases at subsequent power reductions. It was emphasized that further development is necessary in such areas as the microstructure examination of irradiated UO<sub>2</sub>, tests of chemical effects at extended burnup, the effects of transient fission gas release and experiments on gas mixing.

143. The Agency participated in the 8th International Symposium on Zirconium in the Nuclear Industry (June 1988, USA) organized by the ASTM. Insight was gained into actual needs in this area, reaffirming that corrosion and hydriding of current zirconium alloys may be the limiting factors to burnup increase.

144. The Water Chemistry Control and Coolant Interaction with Fuel and Primary Circuit Materials in Water Cooled Power Reactors (WACOLIN) investigation was conducted. A first research co-ordination meeting and a consultants meeting were organized and detailed tasks for the manual of good practices on water reactor chemistry were worked out.

145. A "Review of Fuel Element Developments for Water Cooled Nuclear Power Reactors" was submitted for publication in the Technical Reports Series. The report provides general information on the progress made in water reactor fuel design, fabrication and utilization as well as on current and future developments to satisfy the requirements for extending fuel operating limits. The report is of value to countries with extensive nuclear power programmes, as well as those embarking on national programmes, to provide domestic capabilities for fuel design and manufacture.

146. Two advisory group meetings were organized to initiate the Study on Water Reactor Extended Burnup (WREBUS). The study will focus on an assessment of the economics of high burnup operation, and in particular on the fuel cycle costs of the equilibrium cycle at different burnups and their sensitivities to various parameters. Technical aspects related to fuel design

and manufacturing, in-core fuel management and plant operation will also be discussed, as well as safety and environmental issues.

147. A guidebook on the non-destructive examination of water reactor fuel is under preparation within the framework of the CRP on examination and documentation methodology for water reactor fuel. The second consultants meeting for the preparation of this guidebook was held. The final version will be developed during the third meeting in 1989.

148. New activities related to providing technical co-operation with developing countries were proposed and strongly supported by a number of Member States. A new approach consists in conducting an experimental work programme (including a review of existing data, analyses of results and feedback, etc.) for appropriate laboratories in developing countries, under the guidance of a "supervising expert group". It will provide assistance in the definition of the techniques and procedures, the methods of work and the evaluation of data and results.

149. A number of reports were issued on various aspects of reactor fuel technology: "Advanced Fuel for Fast Breeder Reactors: Fabrication, Properties and their Optimization" (IAEA-TECDOC-466); "Underwater Inspection, Repair and Reconstitution of Water Reactor Fuel" (IWGFPT/29); "Power Ramping, Cycling and Load Following Behaviour of Water Reactor Fuel" (IWGFPT/28); and "Eighth Plenary Meeting of the IWGFPT" (IWGFPT/30).

150. Fourteen technical co-operation projects were supported in nine countries in the areas of: research reactor modernization, nuclear fuel fabrication, nuclear fuel and materials study, nuclear fuel cycle technology, nuclear fuel developments, and simulation of radiation damage. Projects jointly supported with the Division of Nuclear Power included: reactor physics, nuclear power stations and research reactors.

*(d) Spent fuel management*

151. A meeting of the Standing Advisory Group on Spent Fuel Management was held to review the worldwide situation in spent fuel management, define the most important trends in national efforts and international co-operation in this area, exchange information on the present status and progress in the back-end of the nuclear fuel cycle and assist the Agency in formulating the future programme on the subject. As a result of this meeting, IAEA-TECDOC-487, "Spent Fuel Management: Current Status and Prospects", was published.

152. The "Survey of Experience with Dry Storage of Spent Nuclear Fuel and Update of Wet Storage Ex-

perience" was published as Technical Reports Series No. 290. This will provide spent fuel management policy making organizations, designers, scientists and operators of spent fuel storage facilities with the latest information on spent fuel storage technology under dry and wet conditions and innovations in this field.

153. Two consultants meetings were held for the purpose of preparing the second edition of the "Guidebook on Spent Fuel Storage". The new Guidebook will provide a summary of experience and information in many areas related to spent fuel storage and will be submitted for publication at the end of 1989.

154. The CRP on the behaviour of spent fuel and storage facility components during long term storage (BEFAST-II, which started in 1986) continued in 1988 with 15 organizations from 12 countries. Three working subgroups were established to prepare the final report entitled: "Research Development and Practice for Extended Storage of Spent Fuel". Revision of the first draft will be carried out at the second CRP meeting in 1989.

155. A consultants meeting for the preparation of the final version of a report on safe spent fuel storage and possible ways to avoid fuel damage was held. The report is a result of international investigations which started in 1986 and considers the question of how to avoid accidents and how to mitigate their effects if they occur. The report will be submitted for publication at the beginning of 1989.

156. The IAEA Spent Fuel Storage Glossary was published in French (IAEA-TECDOC-354/F) and Spanish (IAEA-TECDOC-354/S). There is now a set of Glossaries - English, French, Russian and Spanish - that provides a basis for improved international understanding of terms used in the important area of spent fuel storage technology.

157. IAEA-TECDOC-461 on "Spent Fuel Surveillance and Monitoring Methods" was published as the proceedings of a technical committee meeting. It covers the state-of-the-art on monitoring and surveillance practice, dry storage issues, criticality factors, future trends and recommendations.

158. A second advisory group meeting on the economics of spent fuel storage was held to revise a first draft and prepare a second one on a methodology for assessment of the economics of spent fuel storage.

159. A technical committee reviewed the subject of the safe management of spent fuel from research reactors, prototype power reactors and commercial power reactors that has been subjected to PIE (post irradiation examination), and developed recommendations for future activity in this field.

160. A special research project on the main principles of the safe removal, conditioning, transportation and storage/disposal of severely damaged nuclear fuel and other accident generated waste was started with the goal of elaborating recommendations on post-accident spent fuel management. The objectives of the study, the content and structure of the final document and the schedule for the study implementation were defined during an advisory group meeting in December.

161. A status report on the "Feasibility of the Separation and Utilization of Palladium, Rhodium and Ruthenium from High Level Nuclear Waste" was prepared. It will be submitted for publication in early 1989.

162. An international study on the effect of radiation on the corrosion of structural materials was initiated. During the first consultants meeting in November the scope and content of an analytical review entitled "An Assessment of Irradiation Corrosion Mechanisms for Zr Alloys in High Temperature Water" were elaborated. In accordance with the recommendations it is planned to create in 1989-1991 a research project on so-called low temperature radiation assisted corrosion in waste management facilities, test reactors, irradiation facilities and reprocessing plants.

163. A manuscript of the report "Nuclear Fuel Cycle in the 1990s and Beyond the Century: Some Trends and Foreseeable Problems" was submitted for publication. The papers in the manuscript provide a good coverage of the state-of-the-art and the dominant trends in the world nuclear fuel cycle, with emphasis on areas of nuclear technology which for one reason or the other are in the shade or disputable at present, but can seriously influence nuclear power development in the future.

## Radioactive waste management

164. The year saw greater Agency involvement in the waste management problems of developing countries. The Waste Management Advisory Programme (WAMAP) has become well established. The national radioactive waste management policies, plans and activities of 12 developing countries were reviewed under WAMAP, with a total of 17 missions since its inception in 1987. In addition, special attention was given to the problems of the control and safe management and disposal of sealed sources (see below). These efforts are of particular relevance to countries with little or no nuclear fuel cycle development or regulatory infrastructures.

165. An international consensus was finally achieved in the area of exemption from regulatory control and a publication on the subject was issued in September in time for the General Conference session ("Principles for the Exemption of Radiation Sources and Practices from

Regulatory Control", Safety Series No. 89). The consensus on principles for exemption was reached at a jointly sponsored IAEA/NEA meeting in Vienna earlier in the year. The principles, which were developed in a joint project between the Divisions of Nuclear Fuel Cycle and Nuclear Safety, find immediate application in efforts aimed at rationalizing the procedures for the management of very low level radioactive wastes.

166. The Technical Review Committee on Underground Disposal (TRCUD) which has guided the programme in the underground waste disposal area for the last ten years has been disbanded to make way for a new advisory committee to be known as the International Radioactive Waste Management Advisory Committee (INWAC). This will have wider terms of reference and will provide advice to the Agency on the whole of its radioactive waste management programme.

167. At the General Conference session in September, a resolution was passed calling upon the Agency to establish an "internationally agreed code of practice" for international transactions involving nuclear wastes. This followed public concern earlier in the year as a result of various reports of illicit exports and dumping of toxic and hazardous wastes in developing countries. A report, prepared jointly between the Division of Nuclear Fuel Cycle and the Legal Division, on the implementation of the resolution is to be submitted to the next session of the General Conference in September 1989.

168. The Agency co-operated with the Commission of the European Communities in organizing an international symposium on the "Management of Low and Intermediate Level Radioactive Wastes" in Stockholm, Sweden, in May. More than 300 experts from 32 countries and 6 international organizations attended. The results showed that effective technologies for the treatment, conditioning, storage, transport and disposal of low and intermediate level radioactive wastes exist in many Member States. New technologies continue to be introduced, however, and those aimed at minimization of wastes will be particularly beneficial for the nuclear industry in the future. The currently most favoured approaches for disposal of these waste types are engineered shallow burial and deep geological placement.

169. A project aimed at improving the availability of information on radioactive waste management to the general public has continued. A consultants meeting was convened and will be followed by the preparation of a source book on the subject. The book is intended to aid authorities in Member States responsible for preparing public information documents and for responding to questions about radioactive wastes.

170. Work was started on a radioactive waste management database with the aim of providing a ready source

of reliable information on the status of radioactive waste management in the Agency's Member States. It is anticipated that this database system will be useful for responding to the many demands on the Agency for information in the radioactive waste management area.

171. The Agency is currently providing support for 26 technical co-operation projects in 19 Member States in the waste management area, and while they cover the whole waste management spectrum, the majority are related to handling, treatment, conditioning and storage, reflecting the main current concerns of developing countries.

*(a) Handling, treatment, conditioning and storage of radioactive wastes*

172. The potential hazards associated with sealed radiation sources have become recognized in recent years as a result of accidents involving human exposure and fatalities. The Agency has introduced a special programme on the management of sealed radiation sources. The programme covers the control of sealed sources in their field of application (Division of Nuclear Safety) and the conditioning and disposal of spent sealed sources (Division of Nuclear Fuel Cycle).

173. Work on a new series of short technical manuals offering practical guidance on the treatment, conditioning and storage of the various types of radioactive waste which can be generated from applications in research, medicine and industry has been started. A video film illustrating methods for the conditioning and storage of certain types of sealed sources has been prepared as an aid for use in training courses and lectures, and presentations during WAMAP and technical co-operation missions.

174. Four reports were published in the Technical Reports Series on the "Treatment of Alpha Bearing Wastes" (No. 287), the "Immobilization of Low and Intermediate Level Radioactive Wastes with Polymers" (No. 289) the "Design and Operation of Off-Gas Cleaning Systems at High Level Liquid Waste Conditioning Facilities" (No. 291) and "Design and Operation of Off-Gas Cleaning and Ventilation Systems in Facilities Handling Low and Intermediate Level Radioactive Material" (No. 292); three other reports in this general subject area were completed and submitted for publication.

175. Three CRPs continue in this subject area on the evaluation of low and intermediate level radioactive waste forms and packages, the performance of solidified high level waste forms and engineered barriers under repository conditions and the use of inorganic sorbents for liquid waste treatment and as backfill at underground repositories.

176. A regional training course on the handling and disposal of nuclear wastes held at the Institute of Atomic Energy in Beijing, China, was attended by 21 participants from eight developing countries.

*(b) Underground radioactive waste disposal*

177. In response to requests from several Member States, the Agency has developed a report intended for publication in the Safety Series, Safety Standards category, entitled "Safety Principles and Technical Criteria for the Underground Disposal of High Level Radioactive Wastes". Comments on an advanced draft have been received from interested Member States and are currently being evaluated. A report entitled "Qualitative Acceptance Criteria for the Radioactive Wastes to be Disposed of in Deep Geological Formations" is at a similar stage of development.

178. The second edition of the Radioactive Waste Management Glossary (IAEA-TECDOC-447) was published. Technical Reports on the "Sealing of Underground Repositories for Radioactive Wastes" and the "Natural Analogues in Performance Assessments for Disposal of the Long Lived Radioactive Wastes", together with a Safety Series report giving guidance for the regulation of underground repositories for disposal of radioactive wastes, were finalized and submitted for publication after being reviewed by the Technical Review Committee on Underground Disposal (TRCUD).

179. Co-ordinated research programmes on the geochemistry of long lived transuranic actinides and fission products and on the migration and biological transfer of radionuclides from shallow land burial have continued.

*(c) Decontamination and decommissioning of nuclear facilities*

180. The programme consists of three components: guidance on the decontamination and decommissioning of nuclear installations; the management of uranium mill tailings; and the cleanup of large areas after a nuclear accident.

181. Reports on the "Decontamination and Demolition of Concrete and Metal Structures during Decommissioning of Nuclear Facilities" and on "Factors Relevant to the Recycle or Reuse of Components Arising from Decommissioning" were issued (Technical Reports Series Nos 286 and 293). Reports on the development of regulatory procedures for decommissioning and on the use of remotely operated equipment in decommissioning and rehabilitation are being prepared. The final

report on the first CRP (1984-1987) on decontamination and decommissioning was submitted for publication and preparations are under way for a second CRP (1989-1992) which will concentrate on decontamination technology.

182. Each year about 50 000 m<sup>3</sup> of uranium mine and mill tailings are produced for each 1000 MW(e) reactor in the world. Research is still going on to find suitable ways to close out mill tailings facilities for long term disposal. A new report reviewing the most recent work in closing out these facilities and on predictive modelling of the migration of radionuclides is being finalized.

183. On the subject of cleanup of large contaminated areas, a report entitled "The Cleanup of Very Large Areas Contaminated as a Result of a Nuclear Accident" was submitted for publication. Reports entitled "Overall Operational Planning for the Cleanup and Control of Very Large Areas After a Nuclear Accident" and "The Safe Transport and Disposal of Very Large Volumes of Contaminated Material" are in the review process.

*(d) Environmental aspects of radioactive waste management*

184. A report which evaluates the impact of deep sea dumping on marine species entitled "Assessing the Impact of Deep Sea Disposal of Low Level Radioactive Waste on Living Marine Resources" was published as Technical Reports Series No. 288 and was presented to the meeting of the London Dumping Convention in September 1988. On a related subject, a report aimed at evaluating the effects of controlled radionuclide releases on terrestrial and fresh water plants and animals is in a final stage of preparation.

185. Work commenced towards answering a number of questions posed by an intergovernmental panel of the London Dumping Convention related to the risks associated with the dumping of radioactive wastes in the marine environment. The Agency is responsible to the Convention as its scientific advisor on all matters relating to radioactive materials.

186. A new CRP was started on the validation of models for the transfer of radionuclides in terrestrial, aquatic and urban environments. This CRP, which is sponsored jointly by the Divisions of Nuclear Fuel Cycle and Nuclear Safety, was recommended to the Agency by the Expert Panel following the post-Chernobyl accident review in 1986. It will utilize the environmental information which became available following the Chernobyl release for the purposes of improving the reliability of environmental transfer model predictions.

187. The principles for exemption of radiation sources and practices from regulatory control (discussed above)

are being applied in a number of areas of waste management and radiation protection. Reports are in preparation related to the application of exemption principles to the recycle of slightly contaminated materials from the fuel cycle, and to consumer products containing

small radioactive sources. A new project on their application to low level wastes from the use of radionuclides in hospitals and research establishments has been started in conjunction with the Division of Nuclear Safety.

# NUCLEAR SAFETY AND RADIATION PROTECTION

## Safety of nuclear installations

188. While nuclear safety is primarily a national responsibility, governments have become increasingly aware of the international dimensions of the safety issue and the benefits of co-operation and shared experience. As a result, an internationally agreed safety regime which can be used voluntarily to complement national efforts is emerging. Largely through the combined efforts of its Member States, the Agency continued in 1988 to serve as an important instrument for building such an internationally agreed safety regime.

189. Responding to the needs of Member States, in 1988 the Agency strengthened its safety evaluation and information exchange services for nuclear power plants and research reactors. The Operational Safety Review Team (OSART) programme included six missions to plants operating or nearing operation in six countries - France, Hungary, Italy, Japan, Sweden and the USSR. Teams of experts from Member States and IAEA staff, together with observers from developing countries, provided impartial international recommendations on operational safety in key areas including management, plant operation, maintenance, training, technical support, radiation protection, plant chemistry, operational feedback and emergency preparedness. Preparatory work began for 1989 missions to Brazil, China, Czechoslovakia, the Republic of Korea, Pakistan, the United Kingdom and the United States. To supplement OSART guidelines, reference material and additional guidance on surveillance and industrial safety were prepared for publication. A second report on the generic findings of OSART missions, synthesizing the results of seven missions from June 1987 to June 1988, was also prepared for publication.

190. Since the programme began in 1983, international teams of some 200 safety specialists have been invited to visit plants in 18 countries and to explore with the people involved how operational safety can be brought to an even higher level. Appropriately, OSART users met in Vienna in June for the first in a series of meetings to compare experience and recommend improvements. Fifteen countries were represented by participants from 20 nuclear power plants and 6 regulatory bodies.

191. As part of its efforts to foster wide feedback of experience among specialists engaged with similar type reactors, the Agency sponsored a meeting on operational safety experience for two-loop pressurized water reactors.

192. The Operational Safety Indicators Programme (OSIP) provides numerical performance indicators of

plant safety that help focus assessments on key areas. Since 1986, the OSIP approach has been used in conjunction with OSART missions. Although in many countries safety indicators are an effective tool for learning about operational safety practices and trends, there is not yet an international consensus on a set of indicators. To promote consistency among the various approaches, the Agency held an open workshop in Vienna for those using such techniques.

193. The Agency's Incident Reporting System (IRS) is the only worldwide service for the exchange of information on operational safety experience, with 24 of the 26 countries with nuclear power programmes reporting directly to the IAEA or through the co-operative regional system of the Nuclear Energy Agency of the OECD. The IRS works by collecting, analysing and disseminating useful information about reported safety related events at nuclear power plants. The aim is to understand safety problems that may be common to specific plant types or generic to all plants and to disseminate this information. By the end of 1988 there were 613 events recorded in the system. The emphasis this year was on analysing the safety significance of the reported events. Meetings were also held throughout the year with utility representatives, nuclear plant operators, national authorities and others using the IRS; these yielded practical suggestions on ways of improving the information reporting and feedback. Computerized IRS information is now available on diskette to requesting Member States.

194. As a complementary activity, the Assessment of Safety Significant Events Teams (ASSET) programme responds to requests for assistance in learning more about the underlying causes and prevention of incidents with significant safety implications. In November an ASSET team visited Brazil and in October the ASSET approach was used to identify generic safety issues from the reported events in the IAEA-IRS.

195. For more than 15 years the Agency has been assisting Member States through its programme for the Integrated Safety Assessment of Research Reactors (INSARR). The 326 research reactors operating in 55 countries in 1988 had a cumulative operating experience of 9814 reactor-years, backed up by an impressive record of safety. Assessments are conducted periodically at research reactors set up with Agency assistance and also upon request. In 1988 INSARR experts visited a reactor facility in Venezuela. Additionally, there were four requested missions - to Colombia, Iraq, the Republic of Korea and Norway - the latter being the first to a facility in a developed country with a large scale experimental programme.

196. Efforts to enhance the operational safety of research reactors have taken on added importance as more than two-thirds of these reactors are at least 20 years old.



For many countries, modification and decommissioning are crucial issues, whereas for other countries, particularly in the developing world, concerns are with safety in siting, designing and operating reactors currently being constructed or planned. Until recently there has been little international guidance available to complement national efforts for research reactor safety. To help fill this gap, the Agency initiated in 1988 a three-year publication programme which will include a Safety Standard report, several Safety Guides and Safety Practices. The first Safety Guide, on design for safety of research reactors, will be finalized for publication in 1989. A CRP on probabilistic safety assessment for research reactors was completed in 1988. The results of this work, which involved 13 institutions from 12 Member States, were documented in a summary report and in three volumes describing case studies of safety features of specific reactor types. Preparations also began for the first international symposium devoted to the issue of research reactor safety, operations and modifications, which will be held in Canada in 1989 under IAEA auspices.

197. In the Agency's Nuclear Safety Standards (NUSS) programme the five Codes of Practice were revised for the first time since the initiative begun over a decade ago, to reflect current thinking and experience gained in accident prevention and management. The revised Codes (for governmental organization, siting, design, operations and quality assurance) were published following technical approval by the NUSSAG advisory group and formal acceptance by the Board of Governors. Translations of the revised codes into four languages were completed for publication in 1989. Work began on updating a selected number of Safety Guides in view of major advances in the state-of-the-art.

198. Although the Codes are not binding, Member States have used them extensively to elaborate national regulations. Virtually all of the Member States with ongoing or emerging nuclear power programmes responded to the Agency's recent questionnaire about their regulatory standards and practices and possible ways to achieve consistency among national regulatory approaches to safety. The results of this inquiry were among the topics discussed at the International Symposium on Regulatory Practices and Safety Standards for Nuclear Power Plants, which was held in Munich by the IAEA, the OECD/NEA and the Government of the Federal Republic of Germany. Nearly 200 specialists from 32 Member States and 4 international organizations participated in the meeting, which provided a unique opportunity to exchange views on good regulatory practices and to explore the notion of organizing non-mandatory international peer reviews of national nuclear regulatory programmes. Following a request by a Member State for such an assessment, the Agency prepared guidelines for a pilot mission in 1989; the title

of this activity was changed to Comparative Studies of Regulatory Activities.

199. In the area of nuclear facility siting, several missions were undertaken in support of technical co-operation projects in the Islamic Republic of Iran, Indonesia and Romania. Other safety missions included the full scale testing of a nuclear installation building in Peru and the assessment of safety relevant damage at a nuclear power plant in the Islamic Republic of Iran. An Agency sponsored training course on civil engineering requirements for the structural design and construction of nuclear power plants was held in Poland, and a workshop on quality assurance siting for nuclear facilities took place in Morocco. The year also saw the publication of two NUSS user manuals - on "Dose Assessment in Nuclear Power Plant Siting", and on the "Prevention and Mitigation of Groundwater Contamination from Radioactive Releases" (IAEA-TECDOC's Nos 450 and 482).

200. Agency computer codes were used by 20 experts to analyse the safety of WWER-type nuclear reactors in four Member States. Experience gained in the use of these codes was among the subjects discussed at three workshops held during the year. A technical document (IAEA-TECDOC-477) was published summarizing the comparative results of the Agency's second "standard problem exercise" conducted jointly with the Central Research Institute for Physics of the Hungarian National Academy of Sciences.

201. The International Nuclear Safety Advisory Group (INSAG) completed its pioneering work on "Basic Safety Principles for Nuclear Power Plants" (INSAG-3). The principles reflect the most advanced policies and practices being pursued at nuclear power plants. The INSAG-3 report and its message have been widely distributed to stimulate feedback on the next steps that the Agency and its Member States could take to assist the nuclear community in its quest for safety excellence. In February, the Board of Governors approved the Director General's proposal to maintain INSAG for another three-year term. Meeting for the first time in November, the new members of INSAG set priorities and defined a plan of action for this period.

202. The INSAG-3 report was among the topics discussed at the International Symposium on Severe Accidents in Nuclear Power Plants, which was held in Sorrento, Italy. The meeting served as a timely forum for exchanging information on the scientific and technical aspects of severe accidents and the rationale and implementation of severe accident practices in several countries. The symposium proceedings were published. A technical committee meeting held in Moscow later in the year focused on the design basis for severe accident containment, including the design and physical characteristics of containment systems, containment loads and

system response, the assessment of reserve margins, and management.

## **Reliability and risk assessment**

203. In the area of probabilistic safety assessment (PSA), the Agency continued to play an important role in facilitating information exchange, advancing PSA methodology, and assisting Member States in the use of PSAs.

204. Within the framework of a regional programme, guidance was given to five Member States in conducting PSAs for WWER-400 type reactors.

205. Agency sponsored training courses were held for PSA analysts and managers, respectively, in Argonne, USA, and Oldbury, United Kingdom, and a course on probabilistic consequence evaluation took place in Dublin, Ireland.

206. An Agency personal computer software package developed for fault-tree and event-tree analysis was distributed to more than 50 users in regulatory bodies, research institutions and utilities in Member States. The package is being adapted for use as a tool for the safety management of nuclear power plants, in co-operation with Member States.

207. Work continued on implementing the CRPs on probabilistic modelling of accident sequences and on the collection and analysis of PSA reliability data. The CRP on the comparison of the cost effectiveness of risk reduction among different energy systems drew to a close. The programme, which included more than 30 case studies carried out by 15 Member States, demonstrated the practicality of this methodology for risk reduction analysis. The final report on the programme is being prepared for publication in 1989.

208. A draft Safety Series document which describes a standardized framework for conducting PSAs in nuclear power plants and for reporting the results was circulated for comment. In another publication, issued as IAEA-TECDOC-478, the Agency reports on the compilation of component reliability data, which are stored in a form facilitating interrogation and information retrieval on personal computers.

209. Progress was made on implementing the inter-agency (IAEA/UNIDO/UNEP/WHO) project for assessing and managing the health and environmental risks of energy and other complex industrial systems. Case studies were initiated in eight Member States, and work began on drafting supporting technical documentation.

210. To keep abreast of advances in operational safety, the Agency sponsored the International Conference on

the Man-Machine Interface in the Nuclear Industry. The conference was held in Tokyo, Japan, in co-operation with the Nuclear Energy Agency of the OECD and the Commission of the European Communities. Nearly 500 specialists from 28 Member States and 4 international organizations discussed problems and prospects for improving the man-machine interface. The conference proceedings were published.

## **Radiation protection**

211. For more than 25 years the Agency has established standards and guidance on radiation protection and assisted Member States in their application to national legislation and practices. In 1982, the Agency, together with the ILO, WHO and the OECD/NEA, developed the Basic Safety Standards for Radiation Protection. These standards, which are based on recommendations of the International Commission on Radiological Protection (ICRP), apply to anticipated situations assumed to occur with certainty. For anticipated situations where the exposure probability is lower than unity (so-called potential exposures), international efforts are under way to formulate protection principles consistent with radiation protection standards. However, for unanticipated (so-called de facto) situations, there is not yet an international consensus on radiation protection principles.

212. The work on radiation protection continued to address these needs, focusing on the development of basic criteria, occupational and environmental protection, radioactive material transport, emergency planning and preparedness, radiation source control, the radiation safety of nuclear fuel related activities, and exposure assessment and handling.

213. The Agency's long-standing co-operation with the ICRP continued, through information exchanges and liaison with ICRP's Main Commission aimed at ensuring consistency in approaches. Among other things, the ICRP is currently revising its basic recommendations and preparing documentation on several subjects, such as the monitoring of internal contamination, optimization in decision making for radiological protection, and the control of probabilistic exposures. Specifically, the Agency has developed practical recommendations for implementing the decision making techniques for optimization set out in the forthcoming ICRP report, and is defining policy criteria relative to probabilistic exposures.

214. The results of activities in environmental assessment and radiation protection were synthesized and reported in a number of documents which are in various stages of publication. A report on the principles for the exemption of radiation sources and practices from regulatory control was published as Safety Series No. 89. The three-year work of extending the principles of

radiation protection to sources of potential exposure drew to a close with the preparation of the final report for publication in the Safety Series. To assist in the application of the principles for limiting environmental releases of radioactive effluents set forth in Safety Series No. 77, a report was finalized which recommends effluent release limits for nuclear power plants and reprocessing plants; work progressed on a related publication describing methods of assessing individual and collective doses. A report recommending principles for setting regional and global dose upper bounds was also finalized for publication in the Safety Series. A document on the use of real-time atmospheric transport models under accident conditions was prepared.

215. Radon exposures account for at least half of the average dose from the radiation in the natural background. To learn more about controlling these exposures, the Agency initiated a CRP for monitoring and assessing both outdoor and indoor radon exposures in the natural environment.

216. The list of consumer products incorporating processed or natural radioactive materials grows steadily, with several million units available on markets worldwide. Normally, the radiation dose people receive from using these products is negligible, but hazards could arise if practices are not properly controlled. An advisory group met to draft a Code of Practice on controlling the uses of consumer products containing radioactive materials; a draft document is being prepared for comment by Member States.

217. Following the Chernobyl accident, Member States supplied the Agency with measurements of radioactivity in environmental materials, and the task of entering these into the Agency's database was completed in 1988. Accompanying software was developed to facilitate data extraction in line with user requirements. In addition to its use by UNSCEAR for analysing exposures from the Chernobyl accident, the database has provided support for two Agency projects: a joint WMO/CEC/IAEA project on the validation of long range atmospheric transport models for use following an accidental release of radioactive materials; and the new CRP VAMP (the validation of models for the transfer of radionuclides in terrestrial, aquatic and urban environments), which is sponsored jointly by the Divisions of Nuclear Safety and Nuclear Fuel Cycle.

218. During 1988, the Agency's traditional relationship with the International Commission on Radiation Units and Measurements (ICRU) was enhanced. Recently, ICRU recommended new quantities for the practical determination of dose equivalents (see ICRU Document 39) and began drafting documentation on calibration techniques and the expected performance of measurement instruments and dosimeters. In line with the Agency's responsibility to assist in implementing

these new quantities, Agency staff worked closely with representatives of the ICRU to ensure that the information provided in these publications would meet the needs of Member States.

219. Particle accelerators are increasingly being used in the fundamental and applied sciences, as well as industrially. To enhance this development, in 1975 the Agency initiated a series of technical reports on radiological safety of accelerator operations. In 1988, the third report in this series appeared, focusing on the safe operation of positive ion accelerators.

220. As in previous years, technical advice was provided for the execution of a variety of technical co-operation projects on radiation protection, totalling over 70 projects in 36 Member States. The Agency also continued to support radiation protection projects within the ARCAL plan of activities - a regional initiative of 14 countries from the region of Latin America. Projects supported in 1988 included one workshop, various training courses, several co-ordinated research and investigation studies and a technical review of activities carried out so far under this plan.

221. In the area of emergency planning and preparedness, work continued on the development of guidance to assist Member States in various aspects of emergency response. Work was completed and four related documents were submitted for publication in the Safety Series on the following subjects: post-accident assessment and recovery in a contaminated environment; on-site habitability in the event of an accident; response to released materials with transboundary impacts; and planning and preparedness for accidents involving radioactive materials in medicine, industry, research and teaching. The Agency also issued a contract for the development of a real-time dose assessment model, which Member States will be able to use on minicomputers for assessing the radiological consequences of atmospherically released radioactive materials. Work under this contract is expected to be completed in 1990.

222. A report entitled "Medical Handling of Accidentally Exposed Individuals" was published in the Safety Series (No. 88). This represents the first in a series of publications dealing with the diagnosis, prognosis and treatment of overexposed people. The second report, on the assessment and treatment of overexposures due to external radiation, draws on the lessons learned from recent accidents to suggest ways of dealing with localized radiation injuries and skin lesions; the document was submitted for publication.

223. Work continued on formulating guidance relating to internal dosimetry and the assessment of internal contamination, and on preparing a document for the Safety Series on the assessment of the occupational intake of radioactive materials.

224. The CRP on the use of realistic chest phantoms for the assessment of plutonium and other actinides deposited in the lung drew to a close. The results of laboratory tests and calibrations undertaken by collaborators using phantoms supplied by the Agency were analysed and documented. In view of the different anatomical, physiological and metabolic data applicable to Asian people, a CRP began this year to compile characteristics of the "reference Asian man". The aim is to provide a suitable basis for dose assessment.

225. The Regulations for the Safe Transport of Radioactive Material, issued in 1962, are continuously updated to reflect developments in practices, technologies, and requirements; the latest revision appeared in 1988 (Supplement 1988 of Safety Series No. 6). Progress was made towards finalizing provisions for the transport of uranium hexafluoride, and work began on formulating air transport requirements for packages with high activity contents, including plutonium.

226. Together with a number of Member States, work began on compiling new databases using personal computer facilities: PACKTRAM (on national competent authority approvals for transport) and EVTRAM (on events in the transport of radioactive materials)

227. Work continued on the CRP aimed at understanding the radiation protection implications of transport accidents. As a complementary activity, a meeting was held in Stockholm which laid the foundations for a new CRP on the development of risk assessment methods in transport safety. The research, which will involve institutions in ten Member States, seeks to develop improved methods and related data applicable to both incident-free transport and accident situations.

228. As a result of the immediate post-Chernobyl difficulties that existed in many countries about how to protect the public from contamination, the Agency has intensified collaboration with WHO, FAO and other organizations in achieving a more uniform approach to the setting of derived intervention levels, particularly for foodstuffs. Safety Series No. 72, which sets out the Agency's guidance on establishing international levels for the protection of the public in the event of a nuclear accident, is being revised; an interim report (IAEA-TECDOC-473) was published in 1988. In related work, a report was completed on monitoring for the immediate radiation protection of the public following a major nuclear accident; this document will reflect recent advances in the state-of-the-art which have taken place since the former Agency guidance was issued on this subject in 1966.

229. At an IAEA/NEA meeting in Vienna, an international consensus was achieved on the exemption of radiation sources and practices from regulatory control. The exemption principles, which are described in a pub-

lication issued in 1988 (Safety Series No. 89), were developed jointly by the Divisions of Nuclear Safety and Nuclear Fuel Cycle. The staff also began work on applying the principles, for example, to consumer products containing radioactive materials and to low level wastes from the use of radionuclides in hospitals and research establishments.

230. Recent radiological accidents and the resulting injuries and fatalities have highlighted problems that can arise when sealed radiation sources are not properly controlled. For many developing countries, the problem of using radiation sources safely is particularly challenging. Early in 1988 the Agency initiated a new programme to address the problems of source control and spent source management. Work began on developing useful guidance on the safe handling of radiation sources and on assisting Member States with the implementation of this guidance. Four documents were submitted for publication in the Safety Series: the safe use and regulation of radiation sources in industry, medicine, research and teaching; emergency planning and preparedness for accidents involving radioactive materials used in medicine, industry, research and teaching; operational radiation protection – a guide to optimization; and the safe handling of tritium. Two meetings held this year resulted in a draft document on the safety aspects of designing and operating gamma and electron irradiation facilities.

231. Two Agency-sponsored international conferences on radiation protection issues, together with the Scientific Meeting on Radiation Protection held concurrently with the General Conference session in September, emphasized the importance the Agency attaches to promoting the safe use of nuclear techniques. At the first gathering – the International Conference on Radiation Protection in Nuclear Energy, held in Sydney, Australia in April – some 350 experts from nearly 60 Member States and 6 international organizations discussed radiation protection principles and policy issues. The Conference proceedings appear in two volumes issued in 1988.

232. The second major gathering, in July, was a post-accident review meeting held in Rio de Janeiro. It served as a timely forum for more than 20 experts from 11 countries and 3 international organizations to examine the causes and consequences of the September 1987 radiological emergency in Goiânia, Brazil. As a follow-up, the Agency published a report on the lessons learned about accident prevention and management.

### **Radiation protection services**

233. For many countries using ionizing radiation, effective radiation protection is especially challenging. This year, Member States continued to show increasing interest in co-operative programmes that employ teams of

international experts to advise on ways of strengthening radiation protection. Upon request, Radiation Protection Advisory Teams (RAPATs) reviewed the infrastructures in 12 countries (Bangladesh, Costa Rica, Côte d'Ivoire, Ethiopia, Greece, Guatemala, Indonesia, Jamaica, Madagascar, Nigeria, Senegal and Viet Nam) and recommended long term strategies for assistance and co-operation in the use and control of ionizing radiation, tailored to the countries' priorities and needs.

234. Three other countries (the Libyan Arab Jamahiriya, Qatar and Zambia) received radiation protection missions (other than RAPAT missions) to advise on measures for ensuring the existence and implementation of effective radiation protection legislation. Two missions to Jordan assessed the radiation protection services at medical installations.

235. In line with RAPAT recommendations, regional projects progressed to various stages for several Member States with common needs for assistance in strengthening their radiation protection infrastructures. In view of the similarity of environmental conditions in Middle East countries, work continued on developing regional capabilities for radiological environmental monitoring. The year also marked the development of a TLD monitoring system, a network of air contamination monitors and a food contamination control system for joint use in the region. Preparations also began for a new project for this region which, among other things, would train employees of national bodies responsible for radiation protection.

236. Within the framework of the RCA project for the Asian and Pacific region, several workshops were conducted at which participants discussed comparative regional studies for environmental and personnel dosimetry and the ongoing work of defining characteristics for the "reference Asian man". To further enhance regional capabilities, the Agency sponsored a regional training course which was held in Sydney in co-operation with Australian authorities.

237. Regional assistance to Member States in Africa included a training course for 14 radiation protection officers, which was held in Nairobi and hosted by the Radiation Protection Board of Kenya. Nairobi was also the venue of an Agency sponsored regional seminar on radiation protection services.

238. Personnel monitoring services continued to be provided on a routine basis to Agency staff, to technical co-operation experts on mission, and to trainees from Member States. For example, 32 000 TL dosimeters were evaluated, 1000 whole body countings and 1100 bioassays were performed, and some 300 fast neutron dosimeters were issued and evaluated.

239. Personnel thermoluminescence dosimetry services were provided to three Member States (Nigeria, Sierra Leone and the United Arab Emirates) in which such services were not locally available.

240. During 1988, there were 37 technical co-operation projects under way for the establishment of national radiation protection services.

## Conventions

241. Member States continued to show increasing interest in putting into force a wide range of binding international conventions covering the early notification of a nuclear accident, multinational assistance for a radiological emergency, the physical protection of nuclear material, and civil liability for compensation for transboundary damage from nuclear accidents.

242. In connection with the international conventions on early notification of a nuclear accident and on emergency assistance, several steps were taken to enhance the response capability of the Emergency Assistance Services. The Emergency Notification and Assistance Technical Operations Manual (ENATOM) was completed for distribution to Member States. Co-operation continued with the World Meteorological Organization on the use of the WMO Global Telecommunication System (GTS) for the rapid transmission of meteorological and radiological data to over 160 national contact points; the IAEA/WMO manual on the use of the GTS under emergency situations was finalized. Internally, the Nuclear Accident/Radiological Emergency Assistance Plan (NAREAP) was finalized, and work is under way to complete a handbook of procedures. The first stage of the technical installation of the Emergency Response Unit (ERU) was completed and tested.

243. On 8 February 1987 the International Convention on the Physical Protection of Nuclear Material entered into force. In February 1988 the Board of Governors requested that the Agency, together with Member States, study the need for updating INFCIRC/225/Rev.1, which includes recommendations on the physical protection of nuclear material. Work is under way in this direction. The eighth international training course on the physical protection of nuclear facilities and materials was held in Albuquerque, New Mexico, USA.

## Nuclear safety review

244. To help Member States keep aware of recent developments in nuclear safety and radiation protection worldwide, the Agency published the sixth edition of the "Nuclear Safety Review". Among other things, the report highlights lessons learned since Chernobyl about accident prevention and management and considers the implications of the 1987 radiological accident at Goiânia, Brazil.

# FOOD AND AGRICULTURE

## Soil fertility, irrigation and crop production

245. Assistance to Member States was provided through 49 research contracts and agreements and 69 technical co-operation projects.

246. Research work aimed at quantitative evaluation of available nitrogen (N) from *Azolla* biofertilizer to flooded rice continued under different management conditions. The results have shown that *Azolla* biofertilizer applied at 30 kg N/ha is as satisfactory as urea as fertilizer. *Azolla* works as a slow release N-fertilizer and losses of N over the first 40 days were 0-10% from *Azolla* but 30-40% from urea.

247. Comparison of nuclear and non-nuclear traditional methods to measure field soil water content continued through a CRP. Results have shown that variances of measurements made with neutron moisture gauges are always lower than with traditional non-nuclear methods, thus requiring fewer measuring sites for a particular level of accuracy. Efforts are being made to compare calibration methods of neutron moisture gauges, including theoretical calibration.

248. Isotope-aided and radiation-aided studies to increase crop production in salt affected soils continued. Different crop species screened for salt tolerance are to be tested for biological amelioration of salt affected soils in field experiments which will be implemented in eight different countries. Research on salinity tolerance mechanisms is also being carried out.

249. The CRP to improve the yield and N<sub>2</sub> fixation of *Phaseolus vulgaris* (field beans) in Latin America continued. Preliminary results have shown that N<sub>2</sub> fixation varies from 25 kg to 165 kg N<sub>2</sub> fixed/ha among 29 lines of *P. vulgaris*. The lines of bean with high N-fixation capacity will soon be adopted by farmers.

250. An interregional training course on the use of isotopes and nuclear techniques in studies of soil-plant relationship with emphasis on root biology and the use of soil resources was held at the Agency's Agricultural Laboratory Seibersdorf. Additionally, a regional training course with emphasis on biological nitrogen fixation was held at Accra, Ghana. Fellows and scientific visitors received specialized training on the use of isotopes and nuclear techniques in soils research at the Seibersdorf Laboratory amounting to 55 person-months.

## Plant breeding and genetics

251. Assistance to 35 Member States was provided through 36 national and 2 regional projects. Training in technologies needed for the application of nuclear tech-

niques in plant improvement was arranged for 62 scientists from 36 Member States through fellowships or courses.

252. Further development of technology was promoted through 35 research contracts, 19 research agreements and 2 technical contracts. The work focused upon the use of doubled haploids in cereals (involving anther culture), and upon in vitro mutation breeding for improving disease resistance.

253. The Plant Breeding Unit at the Seibersdorf Laboratory was strongly involved in the technology development for mutation breeding in response to assistance requests from Member States. An interregional training course hosted by the Laboratory included participants from 19 Member States. Irradiation services for mutation induction were provided free of charge as usual.

254. A consultants meeting on nuclear techniques and plant genetics identified the areas of applied molecular genetics where the Agency should be prepared to assist its Member States in accelerating the development of improved crop cultivars.

255. Through two issues of the FAO/LAEA Mutation Breeding Newsletter, plant breeding institutes in Member States were informed of 275 additional improved cultivars developed by the use of induced mutations and given information on valuable germplasm and technological advances.

## Animal production and health

256. Two CRPs on the use of radioimmunoassay (RIA) techniques to improve the reproductive efficiency of livestock were completed and the results prepared for publication. As a consequence of these activities, RIA techniques have been successfully used to determine the factors which limit reproductive efficiency in indigenous livestock and have helped to improve that efficiency at the small farm level.

257. Work continued under CRPs on the productivity of domestic buffalo in Asia (within the framework of RCA), and on the productivity of sheep and goats in Africa and Asia.

258. Work continued under a CRP on the use of immunoassay techniques in monitoring the reproductive efficiency of indigenous African livestock. This programme is funded from extrabudgetary resources provided by the Technical Assistance Department of the Netherlands Ministry of Foreign Affairs and supported by a regional technical co-operation programme.

259. A CRP was initiated on the development of feeding strategies for ruminant livestock in areas of fluctuating nutrient supply.

260. A regional CRP was initiated on the use of radioimmunoassay, enzyme immunoassay and DNA probe techniques for improving the reproductive efficiency and diagnosis of diseases in Asian livestock.

261. A regional CRP was established for the seromonitoring of rinderpest vaccination in Africa using a standardized immunoassay kit developed at the Agency's laboratory Seibersdorf. This programme is funded from extrabudgetary resources provided by the Swedish International Development Authority (SIDA), and supported by a regional technical co-operation programme.

262. A regional CRP was established to develop improved methods for diagnosing animal diseases in Latin America based on enzyme immunoassay procedures and labelled DNA probes. This programme is funded by the Swedish International Development Authority (SIDA).

263. A regional CRP was established to develop improved methods for diagnosing and controlling trypanosomiasis in cattle and camels in Africa using enzyme immunoassay methods and monoclonal antibodies. This programme is funded from extrabudgetary resources provided by the Technical Assistance Department of the Netherlands Ministry of Foreign Affairs and supported by a regional technical co-operation programme.

264. Within the framework of ARCAL, a training course was organized in Argentina on the use of immunoassay, monoclonal antibody and labelled DNA probe methods for the diagnosis of livestock diseases. The course was attended by 26 scientists from 14 Latin American countries.

265. A training course on the use of immunoassay methods for the serosurveillance of rinderpest in Africa was held in Ethiopia and was attended by 23 scientists from 18 African countries.

266. Research and training continued at Seibersdorf in animal reproduction, disease diagnostics and nutrition. Of particular note is that over 500 000 assay units for progesterone determination by radioimmunoassay and a similar number for monitoring antibody levels to rinderpest by ELISA were distributed to Member States in support of technical co-operation and research contract programmes. The Agricultural Laboratory also provided data on the nutritional value of over 30 agricultural by-products for animal feeding and 40-man/months of fellowship training were provided in radio- and enzyme-immunoassay methods and analytical techniques related to animal nutrition.

## Insect and pest control

267. Assistance to Member States continued through 43 research contracts and agreements, 19 technical co-operation projects, and an interregional training course held in the USA.

268. Development of the Sterile Insect Technique (SIT) for use against the Mediterranean Fruit Fly (medfly) continued through CRPs, technical co-operation projects and support from the Seibersdorf Laboratory. Genetic sexing strains have been developed, including several pupal colour strains and one based on alcohol dehydrogenase. Polytene chromosome maps have been completed. The Peru project was terminated with the clear demonstration that medfly could be greatly reduced, if not eliminated, using a combination of insecticide bait spray and sterile males. A training course on medfly SIT was conducted in Colombia. Medfly larval diet recycling, developed at Seibersdorf, is being transferred to medfly mass rearing facilities in Guatemala and Mexico. When completed, savings of approximately \$1 million per year will be realized. Development of genetic sexing strains is continuing at Seibersdorf, including field evaluation. A search for a *Bacillus thuringiensis* strain effective against adult medflies continued at Seibersdorf.

269. The continued development of the SIT for use against various tsetse fly species was highlighted by a regional co-ordination meeting combined with a regional training course in Vom, Nigeria. The training course emphasized the practical aspects of the SIT for tsetse eradication, including both laboratory and field activities. The research co-ordination meeting summarized 5 years of activities within the programme, including the successful eradication of *G. palpalis palpalis* from 1500 km<sup>2</sup> of Central Nigeria. Also reported was the successful eradication of tsetse flies from a 3000 km<sup>2</sup> area using the SIT in Burkina Faso. Development of new and improved rearing methods for seven species of tsetse flies continued at Seibersdorf. Technology to ship tsetse pupae from regional production centres to field locations is being developed. Other activities include research to sex tsetse flies in the pupal stage and to develop more critical quality control standards. Of particular importance were preliminary data showing that oven dried blood may serve as a replacement for freeze dried or fresh frozen blood for feeding tsetse flies. Plans are being developed for large scale tsetse eradication projects in Ethiopia and Kenya and to obtain resources to initiate the expanded project in Nigeria.

270. The CRP on F-1 sterility is continuing with the probable change to concentrate on one serious Lepidoptera pest, the diamondback moth.

## Agrochemicals and residues

271. Assistance to Member States continued through 62 research contracts and agreements and 13 technical co-operation projects.

272. Co-ordinated research programmes continued on pesticide residues in stored grains, food plants and rice-fish ecosystems, on controlled release pesticide formulations, on the fate of persistent pesticides in the tropics, and on assessing the impact of bound pesticide residues on non-target organisms.

273. Research at Seibersdorf concentrated on the development of improved pesticide formulations for use in the control of tsetse flies and of weeds in paddy rice-fish systems. Radiotracer studies continued at Seibersdorf in connection with an Italian supported project in Kenya and on developing methods for the determination of trypanocidal drug residues in cattle.

274. Development of user friendly and simple radioanalytical methods for use in developing countries was taken up as a new activity.

## Food preservation

275. Assistance to Member States continued through 52 research contracts and agreements, and 23 technical co-operation projects.

276. The activities of the International Consultative Group on Food Irradiation (ICGFI) carried out in its initial phase, from 1984 to 1988, were evaluated at the 5th Annual Meeting of ICGFI in September. In accordance with its mandate, ICGFI monitored and assessed global developments in food irradiation, provided useful 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 on public information about food irradiation was convened to consolidate all safety data related to irradiated foods and irradiation facilities. Training workshops were held on irradiation to ensure hygienic quality of food (Netherlands) and the economic feasibility of food irradiation (Israel). Eight Provisional Guidelines on specific applications of food irradiation were published by ICGFI. A Food Irradiation Process Control School (FIPCOS) for training operators and food control officials was established. The Governments of Ghana and the United Kingdom became members of ICGFI, bringing the total membership to 28. At the 5th Annual Meeting of ICGFI, its members overwhelmingly recommended the extension of ICGFI's mandate for another five years, i.e. until May 1994.

277. The second phase of the Asian Regional Co-operative Project on Food Irradiation (RPFI Phase II), funded by the Australian Government, was successfully completed. The technology on food irradiation had been effectively transferred 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. A proposal for the next phase of RPFI with emphasis on acceptance of irradiated food and control of the irradiation process was submitted to UNDP for possible funding.

278. At the end of 1988, the number of countries where one or more irradiated food items had been approved for human consumption totalled 35; 21 of these countries are using commercial/demonstration irradiators to process several food items on a practical scale.

279. Technology transfer to local industries on food irradiation is also being carried out in Latin America, Europe, the Middle East and Africa through co-ordinated programmes planned specifically for this purpose.

280. An International Conference on the Acceptance, Control of and Trade in Irradiated Foods, jointly sponsored with FAO, WHO and the ITC-UNCTAD/GATT, was held in December in Geneva, Switzerland. The aim of the Conference was to achieve a consensus on the acceptance and control of irradiated foods among Member States. The Conference was attended by more than 250 experts designated by some 60 Member States and 14 inter-governmental and non-governmental organizations. An "International Document on Food Irradiation" was adopted by consensus at the Conference.<sup>8</sup> This adoption indicates that some 60 governments have recognized food irradiation as a method of processing food to reduce food losses and illness caused by certain food-borne pathogens, and to facilitate wider trade of food items. Specific recommendations related to the application of food irradiation, control of and trade in irradiated foods, as well as information dissemination, are included in the Document.

281. The Agreement establishing the International Facility for Food Irradiation Technology (IFFIT) was extended by FAO, the IAEA and the Ministry of Agriculture and Fisheries of the Netherlands for another three years, i.e. until 31 December 1990. IFFIT organized two specialized training courses during 1988.

<sup>8</sup> A number of States (18) expressed their views on the document, stating either endorsement or reservations. Their statements are contained in the proceedings of the Conference.



## LIFE SCIENCES

### Nuclear medicine

282. The programme in the RCA countries for the promotion of bulk reagents for use in radioimmunoassays has been able to significantly reduce the cost of the assays of the thyroid related hormones. It has been possible to introduce self-sufficiency in this region by developing a capability for production of these reagents in several countries. Indigenously produced reagents have been tested in several reference laboratories and those which are found to be acceptable are promoted for use. A data processing programme for quality control has been prepared and distributed to all the participating laboratories. Three national courses were supported (Indonesia, Philippines and Sri Lanka) during the year.

283. A similar programme which started for the ARCAL region a year later is also progressing towards the realization of similar goals. A regional training course was held on the preparation and use of bulk reagents for radioimmunoassay (RIA) of thyroid related hormones in Chile. National courses were held in Costa Rica, Guatemala, Paraguay and Peru, and two national courses in Bolivia. A train-the-trainers course on radioisotope methodology with special emphasis on radioimmunoassay was held in Argentina.

284. Research co-ordination meetings were held during the year for the following CRPs:

- (a) To establish national programmes and investigate their impact on the performance of quality control procedures for nuclear medicine instruments in Asia;
- (b) To establish national programmes and investigate their impact on the performance of quality control procedures for nuclear medicine instruments in Latin America;
- (c) Radioaerosol inhalation for the diagnosis of respiratory diseases in developing countries; distribution of radioaerosol generators, designed and developed locally, has enabled many countries to do lung imaging routinely;
- (d) Promotion of optimum use of bulk reagents for RIA of thyroid related hormones; a reduction in the cost of these assays per patient has been achieved;
- (e) Immunodiagnosis of tuberculosis; the programme will help to make it possible to diagnose tubercular meningitis, a significant cause of morbidity and mortality in children;

(f) Immunodiagnostic techniques for the quantitative determination of circulatory and urinary parasite derived antigens in human schistosomiasis; the proposed techniques are helpful in the specific diagnosis of this infestation;

(g) Nuclear and related techniques for monitoring malaria vectors; the project aims at studying the effectiveness of vector control methods.

285. The programme on the use of nuclear techniques in the diagnosis of communicable diseases has four ongoing CRPs related to malaria, schistosomiasis and tuberculosis. A new programme on the development of diagnostic reagents for communicable diseases using radiation processing techniques was introduced during this year. A regional seminar on nuclear techniques in parasitic and communicable diseases for Asia and the Pacific was held in Bombay.

286. The programme on maintenance of nuclear medicine instruments was rephased and it is now run in co-operation with international organizations such as WHO, UNIDO, IFS (International Foundation for Science) and ICTP. An RCA project formulation meeting on maintenance of nuclear instruments was held in Bombay.

287. An interregional training course on nuclear medicine was held in Moscow and was followed by a study tour. A regional training course was held on medical scintigraphy in Havana, Cuba.

288. An International Symposium on Applications of Dynamic Functional Studies in Nuclear Medicine in Developing Countries and an International Seminar on Training in Nuclear Medicine in Developing Countries were held in Vienna.

289. Technical advice and assistance in the field of nuclear medicine were provided through 67 research contracts and agreements and for 116 technical co-operation projects.

### Applied radiation biology and radiotherapy

290. The latest revision of the Agency's guidelines for the radiation sterilization of medical supplies will be published as an IAEA-TECDOC in 1989.

291. At a research co-ordination meeting held in China, the progress achieved under the RCA programme on sterility quality control of radiation sterilized biological tissue allografts for clinical use in Asia and the Pacific region was reviewed. Radiation sterilized tissues grafts have been applied in clinical trials for performance evaluation and process development.

292. A training course for Asia and the Pacific region on radiation sterilization of tissue grafts for safe clinical use in health care, held in Taiyuan, China, has trained 14 participants from 11 developing Member States (RCA).

293. An interregional seminar on new approaches in practices for radiation sterilization of medical supplies was held in Canada with 16 participants.

294. The final results of two CRPs on the improvement of cancer therapy by combining irradiation with chemical treatment and hyperthermia are to be published as IAEA-TECDOCs.

295. A training course on brachytherapy of cancer of the cervix uteri using manual after-loading, with particular emphasis on guidelines for early diagnosis, was held in Cairo, Egypt, under the auspices of an IAEA/WHO technical co-operation project.

296. Two consultants meetings were held to assist in the radiotherapy programme planning on multimodal approaches for head and neck tumours, and carcinoma of the cervix with emphasis on computer aided dosimetry. The second meeting was an RCA activity.

297. The progress achieved on the use of nuclear techniques in the fermentation of cassava was reviewed by investigators from 12 Member States at a research co-ordination meeting. Radiation-induced microbial mutants showing increased efficiency for starch hydrolysis and nutrient protein conversion in cassava have been isolated and are being tested for pilot scale fermentation studies.

298. Technical advice was provided in connection with 65 research contracts and agreements and 15 technical co-operation projects.

## Dosimetry

299. As the new standing committee, the Scientific Committee of the Network of Secondary Standard Dosimetry Laboratories (SSDLs) reviewed the dosimetry programme and noted that there is an increasing need for accuracy in dose measurement as a result of the introduction of new therapy techniques. The Committee considered that the Agency's programme for improving the coherence and accuracy of SSDL reference instrumentation (CARE) is essential for the entire dosimetry programme.

300. A workshop/seminar on calibration procedures in SSDLs was held in Istanbul, Turkey.

301. A CRP on the testing of the code of practice for absorbed dose determination in photon and electron

beams started and a research co-ordination meeting was held.

302. Another CRP on the development of quality control dosimetry techniques for particle beam radiation processing was initiated.

303. A consultants meeting on the revision of IAEA Technical Reports Series No. 185 ("Calibration of Dose Meters Used in Radiotherapy") was held.

304. The number of radiotherapy centres participating in the  $^{60}\text{Co}$  postal dose intercomparison service being conducted by the Agency and WHO rose to about 340.

305. The performance test of the transportable reference-class ionization chamber dosimeter system for use in radiation therapy was completed and another system for the comparison of radiation protection level secondary standard dosimeters was developed.

306. Routine calibration services and two training periods of two months each were provided by the Dosimetry Laboratory at Seibersdorf for Member States on request.

307. The International Dose Assurance Service (IDAS) for high dose radiation processing and research institutes continued. Reliability of dosimetry in the participating facilities was recognized to be greatly improved.

308. Annual dose intercomparison with thermoluminescence dosimeters (TLDs) was performed for 35 SSDLs.

309. A video film on the Agency's dosimetry activity was completed in English, Spanish and Chinese.

310. Development of a human shaped phantom was completed for investigation of the complete radiation therapy procedure. This programme will be performed in collaboration with WHO.

311. A Technical Reports Series book on "Guidelines on Calibration of Neutron Measuring Devices" (No. 285) and an SSDL Newsletter (No. 27) were published.

312. Assistance to Member States continued through 28 research contracts and agreements and 41 technical co-operation projects.

## Nutritional and health related environmental studies

313. Research co-ordination meetings were held to review progress in CRPs on nuclear techniques for toxic elements in foodstuffs and nuclear and nuclear related

techniques in the study of environmental pollution associated with solid wastes.

314. A CRP (so far with 12 participants) on applications of stable isotope tracers in human nutrition research was initiated.

315. A technical report on minor and trace elements in breast milk (a joint WHO/IAEA collaborative study) was published by WHO. Six articles on analytical quality control and applications of nuclear techniques in human nutrition research were published in international scientific journals. Several newsletters and bibliographies were issued for participants in CRPs.

316. Intercomparisons of enriched stable isotope reference materials for medical and biological studies

(13 reference materials containing deuterium, carbon-13, nitrogen-15 or oxygen-18) were started with the participation of 43 institutes in 21 Member States.

317. An advisory group meeting was held on nuclear techniques in background air pollution monitoring; the report is expected to be published in 1989.

318. Assistance to Member States continued through 72 research contracts and agreements in 42 Member States and 4 technical co-operation projects.

319. Further activities in support of nutritional and health related environmental studies are described in the programmes of the Seibersdorf and Monaco Laboratories.

# PHYSICAL AND CHEMICAL SCIENCES

## Nuclear physics

320. With the objective of improving training in nuclear sciences, the Agency is developing several model training courses in nuclear instrumentation and electronics, nuclear spectroscopy, X-ray fluorescence analysis and the application of personal computers to nuclear experiments. These courses are given on an interregional or regional scale at different technical and scientific levels and are frequently adopted by individual countries for national educational activities. One of the results of this development has been the production of laboratory manuals. Typical example of such courses are nuclear electronics (USA), interfacing in nuclear experiments (Dominican Republic), gamma spectroscopy (Thailand), quantitative X-ray analysis (USA) and advanced aspects of radiation detectors (Argentina).

321. The Agency has developed computer software for specific tasks such as neutron activation analysis, positron annihilation studies, reformatting of spectra and X-ray quantitative analysis. This is an activity that benefits all nuclear laboratories. This software is characterized by its user-friendly interfaces and reflects observations made in laboratories in developing countries.

## Research reactors

322. In 1988 there were 325 research reactors operating in 54 Member States, including 71 in 34 developing countries. The Agency's programme is directed towards: (1) conversion of these research reactors from the use of high enriched uranium fuels to low enriched fuels because of the very limited availability of high enriched uranium fuels, and (2) enhancing the utilization of these reactors to expand the use of research reactors in analytical techniques, radioisotope production for industry, agriculture and medicine and in basic and applied research. These activities continue to be implemented through training courses, symposia, seminars and publications. Reactor physics is emphasized because it relates to all research reactor activities.

## Fusion

323. The International Thermonuclear Experimental Reactor (ITER) project was inaugurated in 1988. An ITER Secretariat was established in Vienna to provide administrative support. Joint design work was carried out by the four participants (CEC, Japan, USA, USSR) at the Max Planck Institute for Plasma Physics in Garching (Federal Republic of Germany). The Definition Phase of this work was completed in October and the report will be published by the Agency.

324. Support for other activities in fusion was provided to both developed and developing Member States. Meetings were organized to exchange information and to investigate modes of increasing collaboration between these countries. New approaches to assist the latter with their fusion programmes were investigated. Several meetings on selected topics in fusion were organized, including the biennial International Conference on Plasma Physics and Controlled Nuclear Fusion Research. The proceedings of the Conference, including the 1988 Artsimovich Lecture, have been submitted for publication.

325. The final INTOR Report was published.

## Industrial applications and chemistry

326. During 1988 the Agency supported 193 technical co-operation projects for 48 countries to promote the transfer of nuclear technologies employed in industry.

327. The final research co-ordination meeting was held on radiation modification of polymers for industrial and medical use. The CRP included the work of seven different groups covering the main trends in radiation polymer research.

328. An advisory group meeting on the assessment of new trends and developments in radiation chemistry was organized. The meeting was attended by 32 participants from 17 countries.

329. IAEA-TECDOC-454 on "Technical and Economic Comparison of Irradiation and Conventional Methods" was published. The report covers the main commercially established industrial radiation applications. Another publication (IAEA-TECDOC-486) on "Radiation Technology for Immobilization of Bioactive Materials" was issued. This contains the final report of a CRP terminated in 1987.

330. Support was provided to 26 bilateral and one regional project (RCA) in the field of radiation technology and engineering.

331. Support was provided to 15 bilateral and two regional projects (RCA, RLA) in the field of NDT.

332. An interregional training course on radiation technology and engineering was organized in Budapest, Hungary.

333. Support was provided to the organization of five national seminars, seven regional training courses and one national training course, all within the scope of the regional project on industrial applications of isotopes and radiation in the South East Asia and the Pacific region.

**334.** A regional seminar on industrial radiation applications was organized in Quito, Ecuador, for the region of Latin America.

**335.** A workshop on radiation processing of flue gases was organized in Madrid, Spain. The seminar was part of activities within the scope of an interregional project on the same subject.

**336.** A first co-ordination meeting reviewed the progress of the CRP on nuclear techniques in the study of pollutant transport with special emphasis on the interaction of solutes with geological media.

**337.** The manuscript of a guidebook on practical aspects of operating a neutron activation analysis laboratory was revised in a consultants meeting. The book is intended as teaching material for developing countries.

**338.** An advisory group meeting discussed the technical and economical benefits of nuclear methods in ore processing. It was shown that considerable savings can be effected. The findings of the meeting will probably be published as an IAEA-TECDOC.

**339.** An advisory group meeting discussed new radioisotope techniques in industry with special emphasis on process control both in steady and non-steady states.

**340.** IAEA-TECDOC-464 on "Current Trends in Nuclear Borehole Logging Techniques for Elemental Analysis" was published. The well established techniques and their applications are described and the development trends discussed.

**341.** IAEA-TECDOC-459 entitled "Nuclear Analytical Techniques for On-line Elemental Analysis in Industry" was published. The results indicated that the techniques are well established, with several hundred installations worldwide.

**342.** At a research co-ordination meeting, recent developments in the synthesis and clinical evaluations of new  $^{99}\text{Tc}^m$  radiopharmaceuticals were discussed. It was concluded that, as far as hepatobiliary imaging agents are concerned, there are already several radiopharmaceuticals available with good characteristics, some of them developed under the auspices of an Agency CRP. Optimized labelling and quality control techniques have also been reported.

**343.** A consultants meeting addressed the current status of the labelling techniques of monoclonal antibodies for radioimmunoscintigraphy. It was shown that the current techniques with I-131 as the label are well developed, and that there are good expectations

that routine techniques in  $^{99}\text{Tc}^m$  labelling will be available soon.

**344.** A report "Isotopic Neutron Sources for Neutron Activation Analysis" was published as IAEA-TECDOC-465. Interesting laboratory experiments are included as a demonstration of the utilization of these modest sources of neutrons for teaching and training.

## Isotope hydrology

**345.** The Agency supported 57 technical co-operation projects in 50 Member States. The fields of co-operation are: assistance in nuclear techniques in the fields of water resources assessment, geothermal resource exploration, strengthening of analytical capabilities and the establishment of isotope laboratories, and the application of nuclear techniques to specific hydrological problems such as those related to sediment transport, leakage from dams and reservoirs, lake dynamics and water pollution.

**346.** Advisory and pre-project missions were undertaken to Cuba, Cyprus, Pakistan, the Syrian Arab Republic, Thailand and Zimbabwe, with the purpose of reviewing the implementation of the on-going projects in isotope hydrology and/or assisting in determining the scope and future needs of national programmes. Also, all Latin American ARCAL countries were visited in order to formulate the programmes for the future ARCAL isotope hydrology project.

**347.** The Agency continues to support research activities in institutes and laboratories in Member States aimed at improving the existing nuclear techniques and developing new ones for use in solving the complex problems of hydrology. At present there are 68 research contracts and agreements in force in 34 Member States. Included are two CRPs dealing with geothermal resource exploration in Latin America (financed by the Government of Italy) and the dating of old groundwater. The latter programme was completed in 1988.

**348.** A consultants meeting on the IAEA/WMO Network of Isotopes in Precipitation was held. The findings of the meeting will form the basis for modifying the existing network.

**349.** The final research co-ordination meeting on the dating of old groundwater discussed the main findings and results obtained during the CRP.

**350.** The second research co-ordination meeting under the programme on the application of isotope and geochemical techniques in geothermal exploration in Latin America was held in Quito, Ecuador. More than 25 geothermal areas have been explored so far. This CRP is expected to terminate in 1990.

**351.** The Agency continues to act as the secretariat for editing three reports, namely on arid zones, sediment transport, and the use of radioactive tracers in groundwater investigations, for the UNESCO-IHP Working Group on Nuclear Techniques in Hydrology.

**352.** An advisory group meeting on the application of isotope and nuclear techniques to the study of hydrology of arid and semi-arid regions was attended by 19 participants from 12 Member States. A technical document on the subject will be published.

**353.** A regional training course on advanced methodologies for isotope applications in hydrology was held in Kuala Lumpur, Malaysia. The course was attended by 29 participants from 11 Member States.

**354.** A training workshop on isotope hydrology was organized in Lisbon, Portugal, within the framework of a technical co-operation project and has promoted the local use of isotope techniques.

**355.** Isotope analyses (oxygen-18, deuterium, tritium, carbon-14) of water samples were carried out in the isotope hydrology laboratory to assist in various technical co-operation projects and research contracts. Inter-comparison and reference samples for isotopic measurements have been distributed.

### **Nuclear data**

**356.** The Agency continued to provide nuclear and atomic data services to Member States and to co-ordinate the activities of a worldwide network of data centres. During 1988 the Agency fulfilled more than 800 requests from 45 Member States for experimental and evaluated data, data processing computer codes and publications. The Agency continued to publish the Bulletin on Atomic and Molecular Data for Fusion on a semi-annual basis and the Computer Index of Neutron

Data (CINDA). Representatives of national and regional nuclear and atomic data centres were convened to improve international co-operation in the compilation, exchange and distribution of nuclear and atomic data.

**357.** As part of its continuing effort to keep abreast of the nuclear data requirements of nuclear science and technology, the Agency convened expert groups to review the status of and assess the requirements for atomic and molecular data needed in radiotherapy and in fusion plasma research, and for nuclear data in the assessment of the influence of target and sample properties on nuclear data measurement. Also a continuing effort was devoted to the development of nuclear and atomic data bases to be used in the design of fusion reactors.

**358.** In order to stimulate work on necessary new nuclear data and to improve the accuracy of existing data, the Agency convened research co-ordination meetings on the measurement and analysis of the cross-sections for the emission of neutrons in 14 MeV neutron reactions and of the spectra of the emitted neutrons, as well as on the methods for the calculation of the data describing the reactions of high energy neutrons with structural materials in fission and fusion reactors. A group of consultants reviewed recent developments in the physics of neutron emission in the fission process.

**359.** A workshop on applied nuclear theory and nuclear models used to calculate data to describe nuclear reaction mechanisms was held in co-operation with the International Centre for Theoretical Physics. As part of the support for training in the performance of accurate measurements for nuclear applications, the Agency continued an interregional project on nuclear measurement techniques. At Headquarters, four fellows received training in various aspects of bibliographic and numerical data processing.

## Selbersdorf Laboratories

### I. AGRICULTURE LABORATORY

#### Activities in support of the joint FAO/IAEA agricultural programme

#### Soil fertility, irrigation and crop production

360. Selected nitrogen fixing trees having a high nitrogen fixation ability in combination with suitable microsymbionts were identified. Constraints in nitrogen fixation of selected tree species were investigated using isotope techniques. Isotope aided experiments on species/cultivar differences with regard to fertilizer and water use and tolerance to deleterious soil conditions (acidity, salinity, etc.) were carried out. Nitrogen fixation studies in grain and forage legumes using nuclear and related methods continued, the aim being to improve productivity in these crops. Soil water management studies through nuclear techniques continued.

361. Services to CRPs and technical co-operation projects continued through analytical assays of about 15 000 samples in connection with the determination of nitrogen-15 and other isotopes and with the dispatch of nitrogen-15 labelled fertilizers to research contract holders. Further development work aimed at the improvement of routine nitrogen-15 analyses was carried out.

362. Twenty scientists attended a six-week inter-regional training course on the use of nuclear techniques in soil-plant productivity with emphasis on root studies. In addition, 12 fellows and 5 scientific visitors received specialized training for a total of 56 months.

363. Support was provided to 12 technical co-operation projects, and staff members carried out a number of pre-project assistance and other missions to Member States.

#### Plant breeding and genetics

364. Research and development for crop improvement were focused on in vitro mutation breeding technology with emphasis on tropical crops such as plantain, banana, cassava, yam, ginger and cocoa. Mutant plants obtained in the Laboratories are presently under evaluation in the field in Member States in tropical conditions. Cell manipulation and in vitro plant regeneration techniques were developed with the objective to use them in combination with nuclear techniques for the mutation

breeding of vegetatively propagated crops. Radiation induced genetic variations were studied in the *Azolla-Anabaena* symbiotic system for selection of variants tolerant to herbicides, high salinity and toxic aluminium levels.

365. Twenty scientists and plant breeders from developing Member States participated in an inter-regional training course on mutation breeding and 7 fellows received training for a total of 39.5 months. In addition, 9 senior scientists visited the Plant Breeding Unit as scientific visitors.

366. About 800 seed samples and several tissue cultures were irradiated as a service to plant breeding institutes in Member States.

#### Animal production and health

367. In order to support scientists in developing countries with disease diagnosis and to complement existing facilities, a laboratory was established for the production of monoclonal antibodies in support of RIA and ELISA kits.

368. Work continued on the characterization of agro-industrial by-products and other non-conventional feed resources using the rumen simulation technique and on the formulation of balanced ruminant diets designed to optimize the use of locally available feed resources.

369. ELISA plates for assessing 600 000 samples for the diagnosis and the epidemiological study of several viral, bacterial and parasitic infections and over 2500 radio-immunoassay kits (equivalent to 250 000 assay units) were supplied to technical co-operation and research contract counterparts. The development of an ELISA kit for measuring the reproductive hormone progesterone was initiated.

370. Staff members instructed in four regional training courses and four fellows received training either in animal nutrition work or in the use of radioimmunoassay techniques.

#### Insect and pest control

371. Colonies of six species of tsetse flies were maintained to provide material for research at the Agency's Laboratories and co-operating institutes in Europe and Africa. Research was conducted to improve the dietetics and cage design for rearing. Crosses of tsetse fly subspecies were made to study the production and characteristics of hybrid progeny. Techniques were developed to colour-mark adults for release in field

studies. The effects of various ambient conditions on puparia packaged for shipment were determined.

372. A new mutant pupal dimorphic strain of Mediterranean fruit fly was developed for genetic sexing. This strain was adapted to mass rearing techniques and after many generations has shown very little recombination. Cytogenetic analyses were made to characterize and compare the chromosomal characters of the mutant and normal wild type strains. Morphological characters were found which can be used to distinguish immature medflies that have been exposed to doses of radiation used for the disinfection of fruit.

373. Four fellowship holders and eight scientific visitors were received in the Entomology Unit.

### Agrochemicals and residues

374. Research was conducted to develop controlled release insecticide formulations for tsetse fly control. Several UV absorber compounds were tested in order to stabilize deltamethrin insecticide on cotton fabric target screens for tsetse. Among the tested compounds, 2,4-dihydroxy-benzophenone provided the best protection to deltamethrin against UV radiation. Several vegetable oils were also tested for prevention of leaching of insecticides with water. Corn oil provided better protection than the other oils tested. Initial tests have indicated that other pyrethroid insecticides can also be stabilized against environmental degradation by using UV absorber compounds and oils. Support was provided to co-ordinated research and technical co-operation projects. This support included supply of radiolabelled pesticides and formulations and visits to Member States for on-site training of local staff by scientists of the Agency's laboratories.

## II. PHYSICS-CHEMISTRY-INSTRUMENTATION (PCI) LABORATORY

### Activities in support of the Life Sciences programme

#### (a) Environment and nutrition

375. The programme on Fallout Radioactivity Monitoring in Environment and Food (MEF) was additionally supported by the effort of two cost-free experts from Canada and the United States. A consultants meeting was held in September, where it was strongly recommended that a CRP on rapid instrumental and separation methods for monitoring radionuclides in food and environmental samples be established. A four-week interregional training course on the determination of radionuclides in food and environmental samples was

organized in co-operation with the Federal Republic of Germany at the Nuclear Research Centre in Karlsruhe. A two-week regional workshop on gamma spectrometry was organized in June in Ljubljana, Yugoslavia, and a one-week national workshop was organized in December in Istanbul, Turkey.

376. The low level actinide laboratory was completed. A rapid separation method (one-day) for the determination of  $^{238}\text{Pu}$ ,  $^{239,240}\text{Pu}$  and  $^{241}\text{Am}$  in sludges from active waste incineration facilities was developed. A rapid Pu analysis procedure for grass samples was tested.

377. A rapid radiochemical method (one-day) for  $^{90}\text{Sr}$  analysis in grass samples and other biological materials was elaborated. A Guidebook on the "Determination of Radionuclides in Food and the Environment" has been prepared for publication in the Technical Reports Series.

378. During 1988, 41 different environmental and food samples were analysed for various Member States. Advice and assistance were provided to 15 Member States under technical co-operation programmes with the aim of establishing or improving national capabilities for analysis of radioactivity in food and environmental samples.

379. Both analytical and technical support were given to two CRPs in co-operation with the Division of Life Sciences. A total of 173 freeze dried total diet samples were homogenized and aliquoted under clean conditions and 1730 subsamples shipped to participating laboratories. In addition, six intercomparison runs and numerous analytical services were performed to support the AOCS programme and to meet the needs of other Sections and Member States. This resulted in about 4000 determinations of various trace elements in approximately 1150 different samples using the various analytical methods available, e.g. NAA, ICP, AAS, fluorimetry, liquid scintillation counting and photometry.

380. A new technique for homogenizing large amounts of freeze dried diet samples at room temperature, using a blender equipped with titanium knives, was developed for environmental and biological materials. This resulted in a decrease of the sample process time from 2 hours to 5 minutes. Digestion bomb and microwave techniques for destruction of samples were also elaborated.

381. The analytical capabilities of the laboratory were further extended through studies on the use of laser fluorimetry for the determination of U in biological samples. A radiochemical procedure for the determination of selenium in biological materials and diets was also developed. Using AAS, the detection limit of the toxic elements Pb and Cd was improved to  $10^{-12}$  g. Using



preconcentration and matrix separation techniques, the recommended Pb value for the total diet reference material H-9 was updated. The reliability of the determination of Al in diets with special reference to the interfering elements, e.g. Ca, Mg, Fe, by using ICP was improved.

**382.** Grass, mat and soil samples from 14 locations in European and Mediterranean countries were collected, processed and sent to laboratories of ten Member States for analyses of fallout radioactivity. Results from seven laboratories were returned, compiled and sent back for review. More samples of grass, mat and soil were received for preparation and distribution in the continuing Grass Ecosystem Project.

*(b) Radiation dosimetry*

**383.** The routine quality control programme, which represents a prerequisite for providing adequate services to the SSDLs of the Network, was regularly implemented.

**384.** The dosimetry laboratory organized and evaluated the fourth postal dose intercomparison with TLDs for SSDLs of the IAEA/WHO Network. Participation increased by about 50%, i.e. from 23 to 35 SSDLs. The results demonstrated high performance levels. BIPM participated with reference irradiations. Seven Canadian radiotherapy centres were included in the intercomparison.

**385.** The dosimetry laboratory continued to provide postal dose intercomparison services for radiotherapy hospitals in co-operation with WHO. Upon request from WHO, 340 TLD kits were prepared and dispatched for use in 340 hospitals. Preparative measurements were also initiated to extend the established postal dose intercomparison service for hospitals from cobalt-60 to high energy photons and electrons and to provide experimental support to the CRP on testing the Agency's international code of practice for absorbed dose determination in photon and electron beams.

**386.** The programme for improving coherence and accuracy of SSDL reference instrumentation (CARE programme) went into routine operation. After successful completion of extensive tests of the CARE programme dosimeters (two sets of two ionization chambers/electrometers) by OeFZS (Austria), OMH (Hungary), NBS (USA) and the Agency's Laboratory, seven SSDLs participated in the CARE programme. One additional dosimeter set was calibrated by PTB (Federal Republic of Germany).

**387.** Calibration irradiations were performed continuously for the Agency's radiation protection services and upon request from Member States. Five reference class dosimeters were calibrated and dispatched. They will serve as secondary standard dosimeters in the SSDLs of Chile, Iran, Pakistan and the Syrian Arab Republic. Upon request from Zimbabwe, an ionization chamber dosimeter was calibrated for use in a radiotherapy department. A soft X-ray chamber was calibrated by BIPM to extend the laboratory's range of secondary standardization to low energy X-rays.

**388.** Expert support was provided for technical co-operation project ALG/1/005. Preparative measurements for and participation in the regional workshop/seminar on calibration procedures in SSDLs in Istanbul, Turkey, occupied six person-weeks. Ten scientific visits requested by TCAC, each lasting between three and five working days, took place at the Unit's laboratory.

**389.** During two training periods of two months each, a total of eleven months of training was provided to six fellows.

### **Activities in support of the Physical and Chemical Sciences programme**

*(a) Chemistry and analytical quality control*

**390.** Four intercomparisons were completed. Six intercomparisons, including those involving radioactivity measurements, are still running. Laboratories in about 50 countries took part in these exercises. At present 48 reference materials are available. The laboratory dispatched materials to respond to 750 individual orders from different Member States. Approximately 900 inquiries about the programme were received. About 700 individual trace element and radionuclide determinations were performed for homogeneity testing and characterization of intercomparison samples. One material was collected, 23 are being processed and 17 are presently on stock.

**391.** The catalogue of the AQCS programme for 1988 was distributed and the new one for 1989 was prepared. An in-house meeting for planning the 1989 programme was organized.

**392.** The mailing list of AQCS was updated and at present contains about 5000 addresses from 139 different countries.

**393.** Two fellows received a total of 24 months of training in the use of various analytical methods based on radiochemical procedures and radioactivity measurements.

*(b) Hydrology*

394. Approximately 2500 water samples were analysed for oxygen-18, 1400 for deuterium, 1300 for tritium, 150 for carbon-14 and 380 for carbon-13 content in support of technical co-operation projects and in order to obtain data for the global precipitation monitoring network. Chemical analyses were performed on 210 samples.

395. The construction of an automated mass spectrometer for oxygen-18 measurements was completed and the equipment was put into routine operation.

*(c) Instrumentation*

396. A stack monitoring system with an automatic data recording and evaluation system for on-line measurement of radioactivity in particulates, iodine and noble gases released from a research reactor was designed and constructed for project GRE/4/008.

397. Computer based 8 channel fly mills with special electronics, needed for evaluating the kinetic energy of insects, were developed for research activities in the Entomology Unit.

398. An X-ray fluorescence laboratory for the provision of training and analytical services and to back up relevant technical co-operation projects in Member States was installed.

399. About 50 nuclear measuring instruments of different types received from Member States and from various Units of the Agency's Laboratories were repaired and serviced.

400. More than 1800 scientific instruments were properly recorded in a new inventory system with the objective to assist in instrumentation maintenance and service. Two hundred and eleven items were selected as key instruments for future implementation of preventive maintenance.

401. A constant voltage transformer with a built-in drop-out relay was evaluated. Recommendations were given to the manufacturer for introducing improvements which would meet the operational conditions of developing countries. The software "Book Mark" was also evaluated with the aim of replacing an expensive uninterrupted power supply, and is now recommended to Technical Officers.

402. A computer program for the accountability of fissile materials (FIMAS) was implemented. The program is now used in the bookkeeping of incoming,

outgoing and stored radioactive materials at the Agency's Laboratories at Seibersdorf.

403. Two programs for expanding the personal computer local area network, UTI-NET, were developed. More peripherals were connected to the laboratory network.

404. The first group fellowship training in nuclear spectroscopy instrumentation maintenance was attended by four senior technicians and engineers from developing countries. The second group fellowship training for six participants was prepared and started during 1988.

405. Twelve fellows received a total of 38 months of on-the-job training in nuclear electronics and in servicing nuclear instrumentation.

406. Expert support was provided to technical co-operation projects and training courses. Several of staff members of the Unit carried out technical missions to the Dominican Republic, Greece, Guatemala, Italy, Jordan and Niger for a total of 87 person-days.

### III. SAFEGUARDS ANALYTICAL LABORATORY (SAL)

#### Activities in support of the Safeguards programme

407. From the 1st of January to the 9th of December 1988, SAL received 733 samples of uranium (603 in 1987), 261 samples of plutonium or mixtures of uranium and plutonium (265 in 1987), and 186 samples of spent fuel solution (306 in 1987). Seventy-three of the 186 spent fuel solution samples were analysed at laboratories belonging to the Agency's Network of Analytical Laboratories (NWAL). Nine samples of heavy water were analysed by a laboratory belonging to the network.

408. The median total time needed in 1988 to conclude verification by off-site destructive analysis was reduced by 21%, 9% and 14% for uranium, plutonium product and spent fuel solution samples respectively, compared to 1987.

409. SAL and NWAL analysed 25 uranium oxide pellets for the characterization of working standards for on-site non-destructive assay. In addition, in the course of testing or improving procedures and in the certification of working reference and quality control materials for off-site destructive analysis, 1640 measurements were performed by SAL and NWAL.

410. In collaboration with the Safeguards Divisions of Operation (SGO), the procedures for collecting and

conditioning of samples in several safeguarded facilities were defined and established. In this framework training courses for new and experienced safeguards inspectors were organized.

411. In collaboration with the SGO and with the help of support programmes of Member States, SAL tested a quadrupole thermal ionization mass spectrometer, studied the application of X-ray fluorescence for potential use in on-site destructive analyses and participated in the qualification of the hybrid K-edge instrument. A similar instrument was ordered. This will be installed at SAL to provide in-house capability for training and technical support.

412. More selective or efficient techniques, namely McDonald and Savage electrochemical titration and high resolution gamma spectrometry (HRGS), were adapted to the analyses of 3 mg plutonium samples and put into routine use. Applications of robots for the chemical treatment of spent fuel and plutonium samples have been studied. These robots will be installed and tested in 1989 with the aim of halving the time needed to prepare the samples, reducing the level of radiation exposure of the operators and to improve the quality of the measurements.

413. A new software package for quality control was developed and implemented in conjunction with support programmes. New hardware which will allow an expansion of the SAL information system (LIS) and improvement of the quality control programme was ordered.

## International Laboratory of Marine Radioactivity

414. During the year the Laboratory continued its ongoing quality control programme by conducting two worldwide intercalibration exercises for concentrations of man-made and natural radionuclides in natural samples. More than 40 laboratories participated in the analysis of a fish flesh reference standard and a marine sediment. New intercomparison samples that are now in different stages of preparation and that will be available for distribution during 1989 include: a Baltic Sea marine sediment sample collected after the Chernobyl accident; a sea plant (*Posidonia oceanica*) and seaweed collected in late 1986 from the local environment at Monaco; and a recent tuna sample from the Mediterranean.

415. As part of the ongoing project on comparative behaviour of radionuclides in the oceans, the Laboratory participated in a sampling cruise to the Black Sea from 21 June to 8 July 1988. Scientists from Canada, France, the Federal Republic of Germany, Netherlands, Turkey and the United States collaborated on different legs of

the cruise. Water samples for plutonium oxidation state measurements were collected and processed on board. Additional water samples were collected for technetium analysis in collaboration with the Cekmece Nuclear Research and Training Centre, Istanbul, Turkey.

416. The first publication concerned with the inventories of selected radionuclides in the oceans went to press in late 1988. Included in the first report are the global oceanic inventories up to 1985 of  $^{14}\text{C}$ ,  $^{137}\text{Cs}$ ,  $^{210}\text{Pb-Po}$ ,  $^{226}\text{Ra}$  and Pu isotopes. Additional reports in this series will include global ocean inventories of  $^3\text{H}$ ,  $^{60}\text{Co}$ ,  $^{99}\text{Tc}$ ,  $^{129}\text{Np}$ ,  $^{241}\text{Am}$ , and long lived isotopes of U, Th, Pa and Ac. Data on these inventories are being assembled to prepare an assessment for UNSCEAR in late 1989 or early 1990 for man-made and natural radioactivities in the oceans.

417. During the year a CRP on sources of radioactivity in the marine environment and their relative contributions to overall dose assessment from marine radioactivity was initiated. Participation of institutions from Australia, Canada, Denmark, the Federal Republic of Germany, India, Italy, Philippines, Portugal, Thailand, the United Kingdom and the United States has been approved, with additional contributions expected in 1989.

418. The effects of organism size and diet on uptake and loss rates of radioactivity were studied with edible mussels exposed in the laboratory to a suite of artificial radionuclides. These studies are important for refining estimates of radionuclide concentration factors obtained through environmental monitoring programmes of Member States. It was found that diet does not significantly affect radionuclide biokinetics in these organisms but that size or age is the more important predictor of the uptake in terms of concentration factors as well as subsequent excretion of radionuclides. Given proper controls and facilities, it has been demonstrated that laboratory experiments can adequately simulate the natural environment for obtaining this type of information.

419. A seasonal study of the vertical transport of plutonium and americium was carried out in the central north Pacific Ocean. Preliminary measurements indicate that the downward flux of transuranic radionuclides is greatest during the periods when biological production in the overlying surface waters is relatively high. These findings suggest that in coastal areas where oceanic biological productivity is generally the highest and artificial particle-reactive radionuclides are often introduced, the removal rate of these radionuclides from the surface layers will be the greatest.

420. To make realistic assessments of the possible impact of artificially introduced radionuclides in the marine environment, a good understanding of natural

radioactivity is important. Studies on Po-210, the most highly accumulated natural alpha emitter by marine organisms and its grandparent Pb-210, a natural fall-out radionuclide, have therefore continued. The Po-210/Pb-210 pair which associate with organic matter are good 'natural tracers' of food chain transfer and other biologically mediated transport processes. These studies are carried out by using a simple, rapid and reliable technique which is highly sensitive and necessitates only small amounts of sample material.

421. The Marine Environmental Studies Laboratory (MESL) continued to consolidate its activities in the development of new methodologies and the provision of comprehensive technical support for regional and global marine pollution assessments in co-operation with other United Nations agencies. The work has included the production of 20 new reference methods, the training of 15 personnel from 7 Member States in techniques for measuring marine pollutants, and the organization of two worldwide and three regional intercalibration exercises for trace metals and halogenated and petroleum hydrocarbons. In addition to this programme, MESL staff attended 13 consultation meetings and workshops in 11 Member States. The MESL service engineer visited laboratories in 15 Member States in the Mediterranean and West and Central Africa. The Laboratory also continued its involvement in regional activities in providing assessment to marine pollution monitoring programmes in these

regions as well as the Gulf region, Southern Asia, South America and the Caribbean.

422. The work of MESL in the Mediterranean region paid particular attention to quality assurance (QA) and training. MESL staff conducted five missions to Member States in north Africa in order to provide training and technical assistance for the implementation of QA programmes. A training cruise was also conducted using a research vessel provided by the Government of Morocco. MESL staff organized five specialist meetings in Monaco to analyse the results of Member States monitoring efforts and to initiate pilot monitoring studies of 'new' contaminants, notably organotin, organophosphorus and organohalogen compounds.

423. During the course of 1988, MESL staff developed a new co-operative programme in collaboration with the FAO/IAEA Joint Division, the CEC and the Government of Mexico in order to apply nuclear techniques to the study of the transport and fate of agrochemical residues in the tropical coastal lagoon environment. This work will commence in 1989.

424. The Laboratory continued to give advice on technical aspects of radionuclides and other contaminants in the marine environment through participation in both the annual Task Group and Executive Group Meeting of CRESP (OECD/NEA Co-ordinated Research and Environmental Surveillance Programmes), and in the United Nations GESAMP Working Group on the State of the Marine Environment.

## INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS

425. The main fields of research and training-for-research at the Centre in 1988 were:

- (a) Fundamental physics (high energy and particle physics, cosmology and astrophysics);
- (b) Condensed matter, atomic and molecular physics (condensed matter and related atomic and molecular physics, materials science, surface and interfaces);
- (c) Mathematics (applicable mathematics, analysis, systems analysis);
- (d) Physics and energy (nuclear physics);
- (e) Physics and the environment (geophysics, climatology and meteorology, physics of oceans);
- (f) Physics of the living state (biophysics, neurophysics, medical physics);
- (g) Applied physics and high technology (microprocessors, communications, lasers, computational physics); and
- (h) Physics and development.

426. 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 4600 person-months; 54% of them were from developing countries, accounting for 81% of the total person-months. One hundred and seventy three of them were associated members from developing countries and 514 of them were researchers from federated institutes in developing countries.

### Fundamental physics

427. Research in high energy physics was carried out throughout the year with the participation of 94 physicists from developing countries out of a total of 165. A two-week school and workshop on superstrings held in April was attended by 70 physicists from developing countries, out of a total of 235. Twenty-three physicists from developing countries, out of a total of 64, took part in the two-week School on Non-Accelerator Physics, while the six-week School in High Energy Physics and Cosmology, including a one-week Conference on Phenomenology in High Energy Physics, was attended by 135 physicists from developing countries out of a total of 195.

### Condensed matter, atomic and molecular physics

428. Research was conducted throughout the year with the participation of 63 scientists from developing countries out of a total of 89. In April-May, an experimental workshop on high temperature superconductors was held in the newly installed training laboratory. A six-week mini-workshop on mechanisms for high temperature superconductivity followed. Altogether, 121 physicists from developing countries took part in these two activities, out of a total of 209.

429. The Spring College on the Interaction of Atoms and Molecules with Solid Surfaces lasted for seven weeks. It was attended by 90 scientists from developing nations, out of a total of 138. It was followed by the three-month Research Workshop in Condensed Matter, Atomic and Molecular Physics during the summer months. Two hundred and forty-one physicists from developing countries, out of a total of 304, took part in it. In August, the Condensed Matter Group in collaboration with the International Union of Pure and Applied Physics organized the 5th Trieste Semiconductor Symposium entitled "Fourth International Conference on Superlattices, Microstructures and Microdevices". Two shorter meetings, the Working Party on Electron Transport in Small Systems (two weeks) and the mini-symposium on Nonlinear Systems (one week) brought together 70 experts, of whom 13 came from developing countries.

### Mathematics

430. Research in mathematics was carried out throughout the year with the participation of 64 scientists from developing countries out of a total of 73. The College on Variational Problems in Analysis which was held in January-February, with a duration of one month, was attended by 176 mathematicians, of whom 77 were from developing countries. A two-week workshop on functional-analytical methods in complex analysis and applications to partial differential equations followed the college. A summer school on dynamical systems followed by a workshop on the same topic assembled 259 mathematicians, of whom 167 came from developing countries, for about 10 weeks. During the October-December period, 189 mathematicians from developing countries out of 287 participants took part in the First Autumn Workshop on Mathematical Ecology (3 weeks) and in the College on Global Geometric Topological Methods in Analysis (1 month).

### Physics and energy

431. A workshop on nuclear theory and nuclear model calculations for nuclear technology applications held in collaboration with the Nuclear Data Section of the

IAEA, brought together for 5 weeks 65 scientists from developing countries out of a total of 90.

### **Physics and environment**

432. A two-week workshop on modelling of the atmospheric flow field, followed by a three-week course on physical climatology and meteorology for environmental applications, was held in May-June. Ninety scientists from developing countries out of a total of 182 took part in them.

433. From October to December, the Centre held a one-month course on ocean waves and tides and a three-week workshop on global geophysical informatics with applications to research in earthquake predictions and reduction of seismic risk; this welcomed 132 scientists from developing countries out of a total of 211.

### **Physics of the living state**

434. The Fourth Summer College in Biophysics devoted to electron transfer in biological systems, the College on Medical Physics and the College on Neurophysics, all lasting for about one month, brought together 202 scientists from developing countries out of a total of 294.

### **Applied physics and high technology**

435. The Second School on Advanced Techniques of Computing in Physics (4 weeks), the Winter College on Laser Physics: Semiconductor Lasers and Integrated Optics (4 weeks), the Second Workshop on Optical Fibre Communications (2 weeks) and the International Conference on the Impact of Digital Microelectronics and Microprocessors on Particle Physics (3 days) were held in January-March. They saw the participation of 241 scientists from developing countries out of a total of 481.

436. The Microprocessor Laboratory welcomed 12 scientists from developing countries out of a total of 13.

### **Adriatico Research Conferences**

437. In 1988, the series of Adriatico Research Conferences included short meetings on: spin and polarization dynamics in nuclear and particle physics; unoccupied electronic states; computer simulation techniques for the study of microscopic phenomena; towards the theoretical understanding of high  $T_c$  superconductors; the application of lasers in surface science; and coherent sources for frontier spectroscopy. Seventy-six physicists from developing countries, out of a total of 426, took part in them.

### **Physics and development**

438. As in the past, a number of the experts and leading scientists taking part in the activities at the Centre lectured on physics and its relevance to development; thirty-two lectures were given in 1988.

### **Training at Italian laboratories**

439. Ninety-six grants were awarded to scientists from developing countries for training at Italian academic and industrial laboratories under a programme which started in 1982 with the financial support of the Government of Italy.

### **External activities**

440. In the field of training for physics and mathematics teachers, the Centre sponsored 104 courses, workshops and symposia in 41 countries. In addition, the Centre sponsored 14 scholarships for scientists wishing to work at 13 research institutions in developing countries; this programme was financed by the Government of Italy.

### **Meetings hosted by the Centre**

441. The Centre hosted seven meetings organized by the Third World Academy of Sciences (3, of which 1 in co-sponsorship with the Canadian International Development Agency), the Astronomical Observatory of Trieste (1), the International Centre for Genetic Engineering and Biotechnology (1), a group of Black American Physicists (1) and the ICTP Office of External Activities (1).

### **Books and equipment donation programme**

442. Under this Programme the ICTP distributed 13 200 journals, 3400 books, 4250 proceedings, 1500 newsletters and scientific journals of general interest and 4350 booklets in various languages among more than 500 institutions in nearly 100 developing countries.

443. Within the framework of this programme, about 50 items of scientific equipment have also been distributed among 5 universities in developing countries.

### **Awards**

444. The 1988 Prize of the International Centre for Theoretical Physics — named this time after the late Werner Heisenberg, Nobel Laureate for Physics 1932, was awarded to Dr. J.N. Onuchle from the University of São Paulo, Brazil, in recognition of his contributions to biophysics.

**445.** The 1988 Dirac Medals of the ICTP were awarded to Professors Efim Samoilovich Fradkin (Lebedev Physical Institute, Moscow, USSR) for his many fruitful contributions to the development of quantum field theory and statistics, and David Gross (Princeton University, Princeton, New Jersey, USA) for his fundamental contributions to the understanding of nuclear

forces at short distances and to the theory of superstrings.

### **Preprints and internal reports**

**446.** In 1988, 428 preprints and internal reports were issued.

# SAFEGUARDS

## Safeguards statement for 1988

447. In 1988, 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.<sup>9</sup> It is considered reasonable to conclude that the nuclear material under Agency safeguards in 1988 remained in peaceful nuclear activities or was otherwise adequately accounted for. This statement is based on the latest 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

448. As of 31 December 1988 there were 168 safeguards agreements in force with 99 States, compared to 166 agreements with 97 States at the end of 1987, a safeguards agreement with Nigeria pursuant to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) having entered into force in February and unilateral submission agreements with Albania and India having entered into force in March and September respectively. A unilateral submission agreement with Spain ceased to be in force in June under the terms of the agreement.

449. A safeguards agreement pursuant to the voluntary offer by China to place some of its civilian nuclear facilities under Agency safeguards was concluded. Also agreements were concluded with Panama pursuant to NPT and the Treaty for the Prohibition of Nuclear Weapons in Latin America (Tlatelolco Treaty), with St. Lucia pursuant to NPT, and with the United States of America pursuant to Additional Protocol I of the Tlatelolco Treaty.<sup>10</sup>

450. Safeguards were being applied in 41 States under agreements pursuant to NPT or to NPT and the Tlatelolco Treaty, in one State pursuant to the Tlatelolco Treaty and in eleven States under agreements pursuant to INFCIRC/66/Rev. 2.<sup>11</sup>

451. 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, un-safeguarded facilities were known to be in operation or under construction. All nuclear-weapon States have un-safeguarded nuclear fuel cycles.

452. Voluntary-offer agreements were in force with four nuclear-weapon States. In accordance with these agreements, certain facilities were designated by the Agency for inspection and were inspected. In one of these States, safeguards were also applied at some facilities under INFCIRC/66/Rev.2-type agreements.

453. On 31 December 1988, there were 511 nuclear facilities under safeguards or containing safeguarded nuclear material (505 in 1987), eight of which were in nuclear-weapon States (nine in 1987); there were also 407 locations outside facilities containing small amounts of safeguarded material (406 in 1987) and two safeguarded non-nuclear installations (two in 1987). In total, therefore, there were 920 installations in 57 States under safeguards or containing safeguarded material (913 installations in 57 States in 1987).

454. At the end of 1988, the nuclear material under Agency safeguards amounted to

10.9 t (8.8 t in 1987) of separated plutonium outside reactor cores;

0.5 t (0.6 t) of recycled plutonium in fuel elements in reactor cores;

254.4 t (224.2 t) of plutonium contained in irradiated fuel;

13.1 t (12.2 t) of high-enriched uranium (HEU);

31 704 t (29 252 t) of low-enriched uranium (LEU); and

54 514 t (50 867 t) of source material.

The greater part of this material was in those States where safeguards were being applied pursuant to INFCIRC/153-type agreements.

455. Safeguards were also being applied to facilities, equipment and non-nuclear material, including 1454 t (1457 t) of heavy water, under INFCIRC/66/Rev.2-type agreements.

9 In the case of voluntary-offer agreements with nuclear-weapon States, nuclear material to which safeguards were being applied was not withdrawn from safeguards except in conformity with these agreements.

10 The agreement with the United States of America entered into force in April 1989.

11 The Agency also applies safeguards to nuclear facilities in Taiwan, China.



## Status of safeguards agreements pursuant to treaty obligations

456. As of 31 December 1988, safeguards agreements were in force with 80 States pursuant to NPT. Fifty-two non-nuclear-weapon States party to NPT had not yet concluded a safeguards agreement in accordance with Article III.4 of the Treaty. However, with the exception of three States, none of these States has, as far as the Agency is aware, significant nuclear activities. Safeguards were being applied in these three States pursuant to other agreements.

457. Eighteen of the twenty-three Latin American States party to the Tlatelolco Treaty have concluded agreements with the Agency pursuant to the Tlatelolco Treaty, as have two States with territories in the zone of application of the Tlatelolco Treaty.

458. NPT safeguards agreements have already been concluded with ten of the eleven States 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.

## Safeguards activities

459. The scale of safeguards activities during 1988 is indicated below:

- 2128 inspections (2133 in 1987) were performed, representing 9379 person-days of inspection (9556).
- 15 500 seals (12 500) applied to nuclear material or Agency safeguards equipment were detached and subsequently verified at Headquarters.
- 1170 plutonium and uranium samples (1340) were analysed, with approximately 3040 analytical results (3600) reported.
- The number of major facilities at which inspection goals were attained for the whole facility was 248 in 1988 (214).
- The number of available inspector staff-years (including inspection assistant staff-years) rose from 179.7 to 184.7 (an increase of 2.8 %), and there was an increase of 4.5 % in the number of available staff-years of designated inspectors (and inspection assistants) for carrying out inspections at facilities.
- The IAEA Offices in Toronto and Tokyo continued to make a significant contribution to effective and efficient safeguards implementation. The electronic communication links installed are now

being used for the exchange of safeguards confidential data, thereby improving the timeliness of processing inspection reports.

- 31 new facility attachments (7 in 1987) were negotiated and 18 updated facility attachments (30) entered into force.

460. In addition, there were considerable achievements in particular inspection-related activities, as can be seen from the following examples :

- Safeguards implementation was initiated at a LEU fuel fabrication plant, in a nuclear-weapon State, with an exceptionally large inventory and throughput and a complex, advanced production line.
- A simultaneous physical inventory verification covering unirradiated natural uranium at all facilities in the natural uranium fuel cycle was successfully carried out for the sixth consecutive year in one State.
- An inspection procedure which includes unannounced inspections for verification of the material flow was implemented at a large fuel fabrication plant.

461. Steps were taken to arrange for the introduction of new or modified safeguards approaches in order to increase the effectiveness and efficiency of safeguards activities. They included the following:

- A new safeguards approach for some on-load refuelled power reactors was developed, including a newly developed core discharge monitoring system backed up in exceptional operating situations by short-notice random inspections.
- Verification of the design information for a new, automated mixed oxide (MOX) fuel fabrication plant was carried out and the facility attachment for the plant entered into force. NDA equipment integrated into the feed transport system was introduced for routine use (the system is designed for continuous, unattended operation).
- A new approach for safeguarding unirradiated MOX fuel in light water reactors (LWRs) was agreed upon with a group of States.
- The development of a safeguards approach for a fast breeder reactor in a nuclear-weapon State was initiated.
- A safeguards approach was successfully devised and implemented at a large plutonium oxide storage facility in a nuclear-weapon State.

- A facility attachment for the storage ponds associated with a large reprocessing facility in a nuclear-weapon State was finalized and agreed upon at the negotiating team level.

### Development and technical support

462. Studies were carried out on a long term programme for improving the effectiveness and efficiency of safeguards, and several sections of the preliminary plan were issued for limited review. In addition, forecasts were produced for the number and types of nuclear facilities coming under safeguards together with the associated quantities of nuclear material.

463. Work continued on the development and improvement of new safeguards approaches for facilities where the approaches currently being used do not provide for the full attainment of the inspection goals as well as for other types of facilities, such as fast breeder reactors (FBRs), highly automated fuel fabrication facilities, long term spent fuel storage facilities, and for LWRs with fresh MOX fuel and fuel assemblies designed for dismantling and re-assembly. In addition, analytical work continued on the further development of fuel cycle safeguards approaches, in particular on the possible application of randomization techniques and the zone approach.

464. The second phase of the United Kingdom supported feasibility study of applying probabilistic methods for the assessment of safeguards effectiveness (PASE) at a model mixed oxide fuel fabrication facility was completed. Planning for a third phase is under way.

465. The Agency participated in the first meeting held under the auspices of LASCAR (Large Scale Reprocessing Plant Safeguards), a forum for the exchange of information on the development of effective and efficient safeguards for large scale commercial reprocessing plants expected to begin operation by the year 2000. The Governments of France, the Federal Republic of Germany, Japan, the United Kingdom and the United States of America and the European Community participate in this forum.

466. Work continued on the development of enrichment monitoring systems for use in the inspection of cascade areas at centrifuge-type uranium enrichment plants. Discussions continued with national authorities on the calibration of their prototype hardware and the design of hardware for inspector use at such facilities.

467. An overall plan for the co-ordination of activities required for the replacement of photographic equipment with closed circuit television (CCTV) systems was developed.

468. The development and quality assurance programmes for an in situ verifiable electronic seal were successfully completed. Ultrasonic seals for in situ verification at CANDU spent fuel storage facilities were tested successfully and authorized for inspection use.

469. Work continued on the development of spent fuel attribute testers allowing in situ verification of light water reactor and on-load refuelled reactor spent fuel. Field trials of prototype units for both types of facilities were initiated. A co-ordinated research programme has been started on the verification of spent fuel without necessitating movement of the fuel.

470. Comprehensive exercises with Cerenkov viewing devices (CVDs) were carried out at light water reactors in Sweden. The procedures for using CVDs were tested and finalized.

471. The co-operation of a Member State with the Agency in the development of an integrated safeguards system for a heavy water production plant continued.

472. The Agency participated in equipment development for an extensive multilateral project with two Member States, to produce a unified safeguards system for a new automated MOX fuel fabrication plant.

473. The following statistics provide an overview of technical services in 1988 (1987 values in brackets):

Twin photo units in use	268	(268)
Photo cameras repaired and tested	301	(364)
Twin photo unit		
failures related to equipment	0.8%	(0.7%)
Surveillance film developed		
at Headquarters	1658	(1794)
Seals verified	15 508	(12 456)
Shipments of equipment	264	(237)
Shipments of nuclear material		
and chemicals	113	(123)
Procurement actions	892	(679)
Samples analysed by SAL and NWAL	1173	(1344)

### Information treatment

474. Computerization of inspection data plays an increasingly important role, and the computer environment must therefore be maintained at a high level of availability and responsiveness. The database and application development environments have been further enhanced with the installation of up-to-date software packages. The installation of a local area network (LAN) for the Department continued. The new IAEA Safeguards Information System (ISIS) system software was completed, allowing the direct transfer of authorized information from personal computers to the central ISIS data base. A number of design proposals

were prepared on the basis of a feasibility study for implementation in 1989.

475. Significant progress in the development of the computerized inspection field support system (IFSS) for one fuel cycle facility was made.

476. Software was developed for the transit matching subsystem which will highlight transfer data reporting large amounts of material which remains unmatched for a certain period, thus permitting the Agency to initiate prompt action to resolve the matter in a timely manner.

477. In order to assist Member States in their review of the semi-annual statements called for in Subsidiary Arrangements for INFCIRC/153-type agreements, such statements have been provided to a number of States in computer readable format.

### **Safeguards evaluation**

478. Altogether 2417 inspection reports (2353 in 1987) and 2612 inspection statements (2508 in 1987) were reviewed. The monitoring of the average time required for the major steps in the processing of statements was continued. The average time between an inspection and the dispatch of the results to the State in which the inspection was performed was 64 days (83 days in 1987).

479. Comprehensive quality assurance audits were conducted, and the implementation of actions resulting from previous quality assurance audits was assessed. Other quality assurance activities included an independent programme for testing the sensitivity of the verification of safeguards seals when returned to Headquarters. This programme submits deliberately altered seals as a blind test of the Headquarters verification. Also, a number of inspection reports were examined, with a quality control review of the associated surveillance films. A system called Low Risk Transition Plan (LRTP) aimed at improving the level of quality of equipment under development has been adapted and further applied to a new model of surveillance equipment.

480. MUF (material unaccounted for) evaluations were done for 52 material balance periods and 45 material balance areas using improved standardized methods.

481. Historical data necessary to define the quality of the measurement systems used in material balance evaluations continued to be collected, primarily from destructive analyses carried out by the Safeguards Analytical Laboratory, the Network Laboratories and by operators. Analysis of these data yielded results important for a statistical evaluation.

### **Standardization and training**

482. A new volume of the Safeguards Manual, dealing with managerial matters, was issued. The preparation of a further volume on safeguards equipment is proceeding. Development of the Safeguards Management Information System (SMIS) continued.

483. Introductory courses on Agency safeguards for new inspectors were conducted, including comprehensive inspection exercises in the German Democratic Republic and in the Soviet Union. Eleven advanced and refresher courses for Professional staff, as well as individual training in the NDA and containment and surveillance (C/S) areas, were held at Headquarters and in the field. Substantial support in the organization and conduct of training courses continued to be provided by Member States.

484. Five safeguards trainees participated in the fifth training programme for junior professionals from developing countries, which included classroom lectures, laboratory experiments and visits to nuclear facilities in Austria and the Federal Republic of Germany. The trainees attended an inspection exercise in the German Democratic Republic. A sixth programme, with five safeguards trainees, will start in January 1989.

485. Two training courses on State Systems of Accounting for and Control of Nuclear Material (SSACs) were organized: a basic course held in the Soviet Union and attended by 24 participants from 22 Member States; and a regional course, designed for Member States from Latin America, held in Brazil and attended by 23 participants from 6 Member States.

### **Support by outside groups**

486. During 1988 SAGSI provided advice on the safeguards development programme and associated meetings planned for 1989-1990 and continued its consideration of guidelines for future safeguards activities on the basis of Secretariat proposals aimed at establishing a long term framework for planning such activities.

487. SAGSI also provided advice on long term guidelines for future safeguards activities relevant to INFCIRC/153-type agreements and began considering similar guidelines relevant to INFCIRC.66/Rev.2-type agreements.

488. An advisory group meeting was held on safeguards related to the final disposal of nuclear material in waste and spent fuel, with emphasis on the termination of safeguards on waste materials.

489. An advisory group meeting reviewed the status of C/S techniques with special reference to in situ verifi-

able seals, made recommendations on the evaluation of performance specifications for such seals, and proposed a basis for a methodology for evaluating the characteristics of C/S devices in field use.

490. A seminar on safeguarding WWER-1000 nuclear power stations was held in the USSR and addressed, inter alia, the safeguards approach, inspection goals and implementation experience for LWRs where access to certain areas within the containment is limited. A seminar held at Headquarters and attended by representatives of facility operators and State authorities reviewed physical inventory verification procedures for LEU and natural uranium fuel fabrication plants. Also, several technical meetings were held at Headquarters and in the USSR on the question of a safeguards approach for the BN-600 fast breeder reactor.

491. A consultant group meeting was convened to study safeguards needs for nuclear reference materials and to consider international co-operation to assure their long term availability.

492. Substantial contributions to the safeguards development programme were again made through national programmes in support of Agency safeguards. Belgium, Canada, France, the Federal Republic of Germany, Italy, Japan, the Soviet Union, Sweden, the United Kingdom, the United States of America and the European Community provided support within the framework of formalized support programmes. Formal support programmes were established with the German Democratic Republic and Finland. Other Member States (notably Argentina, Australia, Austria, Bulgaria, Czechoslovakia, Hungary, the Netherlands, Switzerland and Yugoslavia) continued to contribute through research and development agreements, contracts and test programmes. Further testing and performance monitoring of safeguards equipment for CANDU reactors were carried out in Argentina, Canada, India, the Republic of Korea and Pakistan.

493. Committees and other regular forms of contact between the Agency and Member States, including working arrangements with facility operators, continued to make a significant contribution to the further improvement of safeguards implementation.

**Table 2**  
**States having significant nuclear activities**  
**(at the end of the year indicated)**

	Number of States		
	1986	1987	1988
States with safeguards applied under NPT or NPT/Tlatelolco agreements	41	41	41
States with safeguards applied under Tlatelolco agreements	1	1	1
States with safeguards applied under INFCIRC/66/Rev.2 agreements <sup>a</sup>	11	11	11
NW States with voluntary-offer agreements in force	4	4	4
Other NW States	1	1	1
<b>Total number of States with significant nuclear activities</b>	<b>58</b>	<b>58</b>	<b>58</b>

<sup>a</sup> 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.

Table 3  
Approximate quantities of material subject to Agency safeguards  
(at the end of 1988)

Type of material	Quantity of material (t)			
	INFCIRC/ 153 <sup>a</sup>	INFCIRC/ 66 <sup>b</sup>	Nuclear- weapon States	Quantity in SQ
<b>Nuclear material</b>				
Plutonium <sup>c</sup> contained in irradiated fuel	165.3	30.2	58.9	31 806
Separated plutonium outside reactor cores	9.1	0	1.8	1 355
Recycled plutonium in fuel elements in reactor cores	0.5	0	0	65
HEU (equal to or greater than 20% uranium-235)	12.8	0.3	0	291
LEU (less than 20% uranium-235)	21 977	3 255	6 472	9 654
Source material <sup>d</sup> (natural or depleted uranium and thorium)	33 791	4 154	16 569	4 065
<b>Total significant quantities</b>				<b>47 236</b>
<b>Non-nuclear material<sup>e</sup></b>				
Heavy water	0	1 454	0	75

<sup>a</sup> Covering safeguards agreements pursuant to NPT and/or Tlatelolco Treaty.

<sup>b</sup> Excluding installations in nuclear-weapon States.

<sup>c</sup> The quantity includes an estimated 62.9 t (7861 SQ) of plutonium in irradiated fuel, which is not reported to the Agency under the reporting procedures agreed to (the non-reported plutonium is contained in irradiated fuel assemblies to which item accountancy and C/S measures are applied).

<sup>d</sup> This table does not include material within the terms of sub-paragraphs 34(a) and (b) of INFCIRC/153 (Corrected).

<sup>e</sup> Non-nuclear material subject to Agency safeguards under INFCIRC/66 Rev.2-type agreements.

**Table 4**  
**Installations under safeguards or containing**  
**safeguarded material at 31 December 1988**

Installation category	Number of installations			Total <sup>c</sup>
	INFCIRC/ 153 <sup>a</sup>	INFCIRC/ 66/Rev.2 <sup>b</sup>	Nuclear- weapon states	
A. Power reactors	159	28	1	188 (188)
B. Research reactors and critical assemblies	145	26	1	172 (173)
C. Conversion plants	4	3	0	7 (7)
D. Fuel fabrication plants	30	10	1	41 (41)
E. Reprocessing plants	4	2	0	6 (6)
F. Enrichment plants	5	1	1	7 (7)
G. Separate storage facilities	33	4	4	41 (37)
H. Other facilities	46	3	0	49 (46)
Sub-total	426	77	8	511 (505)
I. Other locations	379	28	0	407 (406)
J. Non-nuclear installations	0	2	0	2 ( 2)
Totals	805	107	8	920 (913)

<sup>a</sup> Covering safeguards agreements pursuant to NPT and/or Tlatelolco Treaty

<sup>b</sup> Excluding installations in nuclear-weapon States.

<sup>c</sup> Numbers for 1987 are indicated in parentheses for comparison.

Table 5

Situation on 31 December 1988 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 <sup>a</sup> (1)	Date of ratification, accession or succession <sup>a</sup> (2)	Safeguards agreement with the Agency (3)	INF/CIRC (4)
Afghanistan	4 February 1970	In force: 20 February 1978	257
Antigua and Barbuda	1 November 1981		
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		
Bolivia <sup>b</sup>	26 May 1970	Signed: 23 August 1974	
Botswana	28 April 1969		
Brunei Darussalam	25 March 1985	In force: 4 November 1987	365
Bulgaria	5 September 1969	In force: 29 February 1972	178
Burkina Faso	3 March 1970		
Burundi	19 March 1971		
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 <sup>b</sup>	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 <sup>c</sup>	3 January 1969	In force: 21 February 1977	193
Dominica	10 August 1984		
Dominican Republic <sup>b</sup>	24 July 1971	In force: 11 October 1973	201
Ecuador <sup>b</sup>	7 March 1969	In force: 10 March 1975	231
Egypt	26 February 1981	In force: 30 June 1982	302
El Salvador <sup>c</sup>	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 5 (cont.)

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT <sup>a</sup>	Date of ratification, accession or succession <sup>a</sup>	Safeguards agreement with the Agency	INFCIRC
(1)	(2)	(3)	(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 <sup>d</sup>	11 March 1970	Accession: 17 December 1981	193
Grenada	19 August 1974		
Guatemala <sup>b</sup>	22 September 1970	In force: 1 February 1982	299
Guinea	29 April 1985		
Guinea-Bissau	20 August 1976		
Haiti <sup>b</sup>	2 June 1970	Signed: 6 January 1975	
Holy See	25 February 1971	In force: 1 August 1972	187
Honduras <sup>b</sup>	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 <sup>b</sup>	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 <sup>c</sup>			
Lao People's Democratic Republic	20 February 1970		
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 <sup>b</sup>	21 January 1969	In force: 14 September 1973	197
Mongolia	14 May 1969	In force: 5 September 1972	188

Table 5 (cont.)

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT <sup>a</sup> (1)	Date of ratification, accession or succession <sup>a</sup> (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 <sup>f</sup>	2 May 1975	In force: 21 February 1977	193
New Zealand	10 September 1969	In force: 29 February 1972	185
Nicaragua <sup>b</sup>	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 <sup>b</sup>	13 January 1977	Signed : 22 December 1988	
Papua New Guinea	25 January 1982	In force: 13 October 1983	312
Paraguay <sup>b</sup>	4 February 1970	In force: 20 March 1979	279
Peru <sup>b</sup>	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 <sup>g</sup>	15 December 1977	Accession: 1 July 1986	193
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		
Sri Lanka	5 March 1979	In force: 6 August 1984	320
Sudan	31 October 1973	In force: 7 January 1977	245
Suriname <sup>b</sup>	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		
Turkey	17 April 1980	In force: 1 September 1981	295
Tuvalu	19 January 1979	Approved by the Board, Feb. 1986	
Uganda	20 October 1982		

Table 5 (cont.)

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT <sup>a</sup> (1)	Date of ratification, accession or succession <sup>a</sup> (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Uruguay <sup>b</sup>	31 August 1970	In force: 17 September 1976	157
Venezuela <sup>b</sup>	26 September 1975	In force: 11 March 1982	300
Viet Nam	14 June 1982		
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

<sup>a</sup> 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.

<sup>b</sup> The relevant safeguards agreement refers to both NPT and the Tlatelolco Treaty.

<sup>c</sup> 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.

<sup>d</sup> 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.

<sup>e</sup> Kuwait signed NPT on 15 August 1968 but has not yet ratified it.

<sup>f</sup> An agreement had also been concluded in respect of the Netherlands Antilles (INFCIRC/229). This agreement entered into force on 5 June 1975.

<sup>g</sup> 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).

Table 6

Situation on 31 December 1988 with respect to the conclusion of safeguards agreements between the Agency and States party to the Tlatelolco Treaty<sup>a</sup>

States party to the Tlatelolco Treaty (1)	Date of becoming a Party to the Tlatelolco Treaty (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Antigua and Barbuda	11 October 1983		
Bahamas	26 April 1977		
Barbados	25 April 1969		
Bolivia <sup>b</sup>	18 February 1969	Signed : 23 August 1974	
Colombia	6 September 1972	In force: 22 December 1982	306
Costa Rica <sup>b</sup>	25 August 1969	In force: 22 November 1979	278
Dominican Republic <sup>b</sup>	14 June 1968	In force: 11 October 1973	201
Ecuador <sup>b</sup>	11 February 1969	In force: 10 March 1975	231
El Salvador <sup>b</sup>	22 April 1968	In force: 22 April 1975	232
Grenada	20 June 1975		
Guatemala <sup>b</sup>	6 February 1970	In force: 1 February 1982	299
Haiti <sup>b</sup>	23 May 1969	Signed : 6 January 1975	
Honduras <sup>b</sup>	23 September 1968	In force: 18 April 1975	235
Jamaica <sup>b</sup>	26 June 1969	In force: 6 November 1978	265
Mexico <sup>b,c</sup>	20 September 1967	In force: 14 September 1973	197
Nicaragua <sup>b</sup>	24 October 1968	In force: 29 December 1976	246
Panama <sup>d</sup>	11 June 1971	In force: 23 March 1984	316
Paraguay <sup>b</sup>	19 March 1969	In force: 20 March 1979	279
Peru <sup>b</sup>	4 March 1969	In force: 1 August 1979	273
Suriname <sup>b</sup>	10 June 1977	In force: 2 February 1979	269
Trinidad and Tobago	27 June 1975		
Uruguay <sup>b</sup>	20 August 1968	In force: 17 September 1976	157
Venezuela <sup>b</sup>	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: <sup>e</sup>			
	Netherlands	In force: 5 June 1975	229
	United States of America	Approved by the Board Sept. 1988 <sup>f</sup>	

<sup>a</sup> 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.

<sup>b</sup> The relevant safeguards agreement refers to both the Tlatelolco Treaty and NPT.

The application of safeguards under an agreement with Mexico in connection with the Tlatelolco Treaty 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 Tlatelolco Treaty and NPT (INFCIRC 197).

<sup>d</sup> An agreement has also been concluded in 1988 pursuant to both the Tlatelolco Treaty and NPT, which has not yet entered into force.

<sup>e</sup> 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.

<sup>f</sup> Entered into force on 6 April 1989.

Table 7

Agreements providing for safeguards, other than those  
in connection with NPT or the Tlateloleco Treaty,  
approved by the Board as of 31 December 1988

Party(ies) <sup>a</sup>	Subject	Entry into force	INFCIRC
(While the Agency is a party to each of the following agreements, only the State(s) party to them is (are) listed.)			
<i>(a) Project Agreements</i>			
Argentina	Siemens SUR-100	13 March 1970	143
	RAEP Reactor	2 December 1964	62
Chile	Herald Reactor	19 December 1969	137
Finland <sup>b</sup>	FiR-1 Reactor	30 December 1960	24
	FINN sub-critical assembly	30 July 1963	53
Greece <sup>b</sup>	GRR-1 Reactor	1 March 1972	163
Indonesia <sup>b</sup>	Additional core-load for TRIGA Reactor	19 December 1964	136
Iran, Islamic Republic of <sup>b</sup>	UTRR Reactor	10 May 1967	97
Jamaica <sup>b</sup>	Fuel for research reactor	25 January 1984	315
Japan <sup>b</sup>	JRR-3	24 March 1959	3
Malaysia <sup>b</sup>	TRIGA-II Reactor	22 September 1980	287
Mexico <sup>b</sup>	TRIGA-III Reactor	18 December 1963	52
	Siemens SUR-100	21 December 1971	162
	Laguna Verde Nuclear Power Plant	12 February 1974	203
Morocco <sup>b</sup>	Fuel for research reactor	2 December 1987	313
Pakistan	PRR Reactor	5 March 1962	34
	Booster rods for KANUPP	17 June 1968	116
	Research reactor and fuel therefor	9 May 1978	266
Peru <sup>b</sup>	Research reactor and fuel therefor	9 May 1978	266
Philippines <sup>b</sup>	PRR-1 Reactor	28 September 1966	88
Romania <sup>b</sup>	TRIGA Reactor	30 March 1973	206
	Experimental fuel elements	1 July 1983	307
Spain	Coral-1 Reactor	23 June 1967	99
Thailand <sup>b</sup> /United States of America	Fuel for research reactor	30 September 1986	342
Turkey <sup>b</sup>	Sub-critical assembly	17 May 1974	212
Uruguay <sup>b</sup>	URR Reactor	24 September 1965	67
Venezuela <sup>b</sup>	RV-1 Reactor	7 November 1975	238
Viet Nam <sup>c</sup>	Fuel for research reactor	1 July 1983	308
Yugoslavia <sup>b</sup>	TRIGA-II Reactor	4 October 1961	32
	Krško Nuclear Power Plant	14 June 1974	213
Zaire <sup>b</sup>	TRICO Reactor	27 June 1962	37
<i>(b) Unilateral submissions</i>			
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 7 (cont.)

Party(ies) <sup>a</sup>	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
Pakistan	Nuclear material	2 March 1977	248
Spain	Nuclear material	18 June 1975	221
	Vandellos Nuclear Power Plant	11 May 1981	292
	Specified nuclear facilities	11 May 1981	291*
United Kingdom	Nuclear material	14 December 1972	175
Viet Nam	Research reactor and fuel therefor	12 June 1981	293
<i>(c) Agreements concluded with nuclear-weapon States on the basis of voluntary offers</i>			
China	Nuclear material in facilities selected from list of facilities provided by China	Signed: 20 Sept. 1988	
France	Nuclear material in facilities submitted to safeguard:	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
<i>(d) Other agreements</i>			
Argentina/United States of America		25 July 1969	130
Austria <sup>d</sup> /United States of America		24 January 1970	152
Brazil/Germany, Federal Republic of <sup>d</sup>		26 February 1976	237
Brazil/United States of America		31 October 1968	110
Colombia/United States of America		9 December 1970	144
India/Canada <sup>d</sup>		30 September 1971	211
India/United States of America		27 January 1971	154
Iran, Islamic Republic of <sup>d</sup> /United States of America		20 August 1969	127
Israel/United States of America		4 April 1975	249
Japan <sup>d</sup> /Canada <sup>d</sup>		20 June 1966	85
Japan <sup>d</sup> /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 7 (cont.)

Party(ies) <sup>a</sup>	Subject	Entry into force	INFCIRC
Japan/United States of America		10 July 1968	119
Japan/United Kingdom		15 October 1968	125
Korea, Republic of/ United States of America		5 January 1968	111
Korea, Republic of <sup>d</sup> /France		22 September 1975	233
Pakistan/Canada		17 October 1969	135
Pakistan/France		18 March 1976	239
Philippines <sup>d</sup> /United States of America		19 July 1968	120
Portugal <sup>d</sup> /United States of America <sup>e</sup>		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 <sup>d</sup>		29 September 1982	305
Spain/United States of America		9 December 1966	92
Spain/Canada <sup>d</sup>		10 February 1977	247
Sweden <sup>d</sup> /United States of America		1 March 1972	165
Switzerland <sup>d</sup> /United States of America <sup>e</sup>		28 February 1972	161
Turkey <sup>d</sup> /United States of America <sup>e</sup>		5 June 1969	123
Venezuela <sup>d</sup> /United States of America <sup>e</sup>		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.

- <sup>a</sup> 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.
- <sup>b</sup> 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.
- <sup>c</sup> 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).
- <sup>d</sup> 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.
- <sup>e</sup> 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.

Table 8

Facilities under Agency safeguards or containing safeguarded material on 31 December 1988

## A. Power reactors

State <sup>a</sup>	Abbreviated name of installation	Location	Subsidiary arrangements in force
Argentina	Atucha NPS	Lima	x
	Embalse PR	Embalse	—
Austria	Tullnerfeld	Zwentendorf	x
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	Bowmanville	—
	Gentilly-2	Gentilly	x
	Pickering-1	Pickering	x
	Pickering-2	Pickering	x
	Pickering-3	Pickering	x
	Pickering-4	Pickering	x
	Pickering-5	Pickering	x
	Pickering-6	Pickering	x
	Pickering-7	Pickering	x
	Pickering-8	Pickering	x
	Point Lepreau G.S.	Point Lepreau	x
Czechoslovakia	A1	Bohunice	x
	Dukovany-2, Unit 1	Dukovany	—
	Dukovany-2, Unit 2	Dukovany	—
	EDU-1, Unit 1	Dukovany	x
	EDU-1, Unit 2	Dukovany	x



Table 8 — A. Power reactors (cont.)

State <sup>a</sup>	Abbreviated name of installation	Location	Subsidiary arrangements in force	
Czechoslovakia (cont.)	V-1, Unit 1	Bohunice	x	
	V-1, Unit 2	Bohunice	x	
	V-2, Unit 1	Bohunice	x	
	V-2, Unit 2	Bohunice	x	
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 1	Greifswald	x	
	Bruno Leuschner-II, Unit 2	Greifswald	x	
	Bruno Leuschner-III, Unit 5	Greifswald	—	
	Rheinsberg PWR	Rheinsberg	x	
Germany, Federal Republic of	AVR	Jülich	—	
	GKW Grohnde	Grohnde	—	
	GKN-2	Neckarwestheim	—	
	KKW Biblis-A	Biblis	x	
	KKW Biblis-B	Biblis	x	
	KKW Brokdorf	Brokdorf	—	
	KKW Brunsbüttel	Brunsbüttel	x	
	KKW Emsland	Lingen	—	
	KKW Grafenrheinfeld	Grafenrheinfeld	—	
	KKW Isar	Ohu bei Landshut	x	
	KKW Isar-2	Essenbach	—	
	KKW Krümmel	Geesthacht	—	
	KKW Mülheim-Kärlich	Mülheim-Kärlich	—	
	KKW Neckarwestheim	Neckarwestheim	x	
	KKW Obrigheim	Obrigheim	x	
	KKW Philippsburg-1	Philippsburg	x	
	KKW Philippsburg-2	Philippsburg	—	
	KKW RWE-Bayernwerk II, Block B	Gundremmingen	—	
	KKW RWE-Bayernwerk II, Block C	Gundremmingen	—	
	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	—	
	VAK-KAHL	Kahl	x	
	Hungary	PAKS-I, Unit 1	Paks	x
		PAKS-I, Unit 2	Paks	x
		PAKS-II, Unit 1	Paks	—
		PAKS-II, Unit 2	Paks	—

Table 8 — A. Power reactors (cont.)

State <sup>a</sup>	Abbreviated name of installation	Location	Su subsidiary arrangements in force
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
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	Shizuoka-ken	x
	Ikata-1	Nishiura-gun	x
	Ikata-2	Nishiura-gun	x
	JPDR	Tokai-Mura	x
	Kashiwazaki-1	Niigata	x
	Kashiwazaki-5	Niigata	—
	Mihama-1	Mihama-Fukui	x
	Mihama-2	Mihama-Fukui	x
	Mihama-3	Mihama-Fukui	x
	N.S. Mutsu	Minato-Machi Mutsu	x
	Ohi-1	Ohi-cho, Fukui-ken	x
	Ohi-2	Ohi-cho, Fukui-ken	x
	Onagawa-1	Tsukahama	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	Iwanai	x	

Table 8 — A. Power reactors (cont.)

State <sup>a</sup>	Abbreviated name of installation	Location	Subsidiary arrangements in force
Japan (cont.)	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	Yangsam	x
	Youngwang 1	Pusan	x
	Youngwang 2	Pusan	x
	Uljin-1	Uljin	—
	Uljin-2	Uljin	—
	Wolsung-1	Ulsan	x
Mexico	Laguna Verde 1	Alto Lucero	x
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	x
	Almaraz-2	Almaraz	x
	Asco-1	Asco	x
	Asco-2	Asco	x
	Cofrentes	Cofrentes	x
	José Cabrera	Almonazid de Zorita	x
	Lemoniz-1	Lemoniz	x
	Lemoniz-2	Lemoniz	x
	Santa María de Garona	Santa María de Garona	x
	Trillo-1	Trillo	—
	Vandellos	Vandellos	x
	Vandellos 2	Vandellos	—
	Sweden	Barsebäck I	Malmö
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	—
Ringhals I		Göteborg	x
Ringhals II		Göteborg	x
Ringhals III		Göteborg	x
Ringhals IV		Göteborg	x

Table 8 — A. Power reactors (cont.)

State <sup>a</sup>	Abbreviated name of installation	Location	Subsidiary arrangements in force
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	Krsko	Krsko	x

**B. Research reactors and critical assemblies**

State <sup>a</sup>	Abbreviated name of installation	Location	Subsidiary arrangements in force
Argentina	RA-1	Constituyentes	x
	RA-2	Constituyentes	x
	RA-3	Ezeiza	x
	RA-4	Kosario	x
	RA-6	Bariloche	x
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.	Ganakhari Savar Dhaka	x
Belgium	BRO2	Mol	x
	BR1-CEN	Mol	x
	BR2-CEN	Mol	x
	CEN-Venus	Mol	x
	Thetis	Gent	x
Brazil	JEAR-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

Table 8 — B. Research reactors and critical assemblies (cont.)

State <sup>a</sup>	Abbreviated name of installation	Location	Subsidiary arrangements in force
Canada (cont.)	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	Vochoz	x
	Univ. Training Reactor VR-1P	Prague	—
	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
Egypt	Nuclear Research Centre	Inshas	x
Finland	Triga II	Otaniemi	x
German Democratic Republic	RAKE	Rosendorf	x
	RRR	Rosendorf	x
	Training Reactor AKR	Dresden	x
	Training research reactor	Zittau	x
	WWR-S M	Rosendorf	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	Garching	x
SUR 100	Furtwangen	x	
SUR 100	Darmstadt	x	
SUR 100	Aachen	x	

Table 8 — B. Research reactors and critical assemblies (cont.)

State <sup>a</sup>	Abbreviated name of installation	Location	Subsidiary arrangements in force
Germany, Federal Republic of (cont.)	Triga	Mainz	x
	Triga	Hannover	x
	Triga II	Heidelberg	x
	BER-2	Berlin (West) <sup>b</sup>	x
	SUR 100	Berlin (West) <sup>b</sup>	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
	Impianto Pec del CNR	Brasimone, Bologna	—
	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	
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	
NAIG-CA	Kawasaki-ku	x	
NSRR	Tokai-Mura	x	

Table 8 — B. Research reactors and critical assemblies (cont.)

State <sup>a</sup>	Abbreviated name of installation	Location	Subsidiary arrangements in force
Japan (cont.)	Rikkyo University R.R.	Nagasaki	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	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	Sucavem	—
Romania	RP-01	Magurele	x
	Triga II	Pitești Colibăși	x
	VVR-S	Magurele	x
South Africa	SAFARI-1	Pelindaba	x
Spain	ARBI	Bilbao	x
	ARGOS	Barcelona	x
	CORAL-1	Madrid	x
	JEN-1 and JEN-2	Madrid	x
Sweden	R2	Studsvik	x
	R2-O	Studsvik	x
Switzerland	AGN 201P	Geneva	x
	AGN 211P	Basel	x
	Crocus	Lausanne	x

Table 8 — B. Research reactors and critical assemblies (cont.)

State <sup>a</sup>	Abbreviated name of installation	Location	Subsidiary arrangements in force
Switzerland (cont.)	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-1	Altos de Pipe	—
Viet Nam	Du-Lat Research Reactor	Du Lat	—
Yugoslavia	RA	Vinča	x
	RB	Vinča	x
	Triga II	Ljubljana	x
Zaire	Triga-Zaire	Kinshasa	x

C. Conversion plants, including pilot plants

State <sup>a</sup>	Abbreviated name of installation	Location	Subsidiary arrangements in force
Argentina	UO <sub>2</sub> Conversion Plant	Cordoba	—
	Uranium Powders Fabrication Plant	Constituyentes	—
Canada	Eldorado Resources Ltd.	Port Hope	x
Japan	Japan Nuclear Fuel Conversion Co. Ltd.	Tokai-Mura	x
	Ningyo R + D	Ningyo	x
	PCDF	Tokai-Mura	--



### D. Fuel fabrication plants, including pilot plants

State <sup>a</sup>	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	CGE	Peterborough	x
	CGE	Toronto	x
	CRNL Fuel Fabrication	Chalk River	x
	WCL	Port Hope	x
Denmark	Metallurgy	Roskilde	x
Germany, Federal Republic of	ALKEM	Hanau	x
	Exxon	Lingen	x
	NUKEM	Wolfgang	x
	RBU-1	Wolfgang	x
	RBU-2	Karlstein	x
India	NFC	Hyderabad	x
Indonesia	Experimental Fuel Element Installation (IERE)	Serpong	x
	Research Reactor Fuel Element Production Installation (IPEBRR)	Serpong	x
Iraq	ERLFF	Baghdad Tuwaiitha	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	Fuel Fabrication Pilot Plant	Daejeon	x
	LEU Fuel Fabrication	Daejeon	x
Romania	Romfuel	Pitești Colibași	x
Spain	Planta Metall. Juan Vigon Res. C.	Madrid	x
	Fuel Fabrication Plant Juzbado	Salamanca	x
Sweden	ASEA-ATOM	Västeras	x
United States	General Electric Co.	Wilmington, N.C.	x

### E. Chemical reprocessing plants, including pilot plants

State <sup>a</sup>	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
Spain	Juan Vigon Research Centre	Madrid	x

### F. Enrichment plants, including pilot plants

State <sup>a</sup>	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	—
Netherlands	Ultra-Centrifuge*	Almelo	—
	URENCO Nederland	Almelo	x
United Kingdom	BNFL Centrifuge plant and associated storage	Capenhurst	x

<sup>a</sup> Location associated with enrichment technology.

### G. Separate storage facilities

State <sup>a</sup>	Abbreviated name of installation	Location	Subsidiary arrangements in force
Argentina	Storage depleted hexafluoride	Bariloche	—
	Storage of 20% enriched uranium	Cac	—
Belgium	BN UF6 store	Dessel	x
	Belgoprocess	Mol	x
	FBFC	Dessel	—
Canada	Bruce A	Tiverton	x
	Bruce B	Tiverton	x
	CRNL	Chalk River	x
	Douglas Point	Tiverton	—
	Gentilly-1	Gentilly	x
	Long term storage at CRNL	Chalk River	—
	Pickering	Pickering	x
	WNRE	Pinawa	x
Chile	Lab. experimental de conversion	Santiago	—
Czechoslovakia	AFRS	Bohunice	—
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	Lubmin	—
Germany, Federal Republic of	Braunkohle	Wesseling	x
	Bundeslager	Wolfgang	—
	E Exxon Nucleur UF6 Lageranlage	Lingen	x
	KFK-FR-2	Eggenstein-Leopoldshafen	—
	Lager II Leese	Landesbergen-Leese	—
	KFA Jülich Lager f. bestr.		
	AVR Kugeln	Jülich	x
	Transnuklear Halle	Hanau	—
Urananlage	Birkenfeld	x	
Iraq	Separate storage facility	Baghdad Tuwaittha	x
Italy	Avogadro	Saluggia	—
	Deposito Prodotti Uraniferi	Bosco Marengo	x
	Ispra Central Storage	Ispra	x
	Lab. di Misura Nucleare Perla	Ispra	—
Japan	KUFS	Kyoto	x
Luxembourg	International Metals S.A.	Luxembourg-Dommeldange	—
Pakistan	Storage at Government depot	Karachi Malir	x
Portugal	Instalação de Armazenagens	Sacavem	x
Sweden	Central long term storage	Oskarshamn	—
Switzerland	Diorit Storage	Würenlingen	x
United Kingdom	BNF PLC Store 9	Sellafield	—
	Sellafield Pu-storage	Sellafield	x
	Oxide Fuel Storage Pond	Sellafield	x

## H. Other facilities

State <sup>a</sup>	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
	KFK-IK/1	Eggenstein-Leopoldshafen	—
	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 Transuran	Jülich Eggenstein-Leopoldshafen	x 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	—
	PNC IRAF	Oarai-Machi	—
	PNC-Oarai R&D	Oarai-Machi	—
	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

Table 8 — H. Other facilities (cont.)

State <sup>a</sup>	Abbreviated name of installation	Location	Subsidiary arrangements in force
Norway	Research laboratories	Kjeller	x
Poland	Institute of Nuclear Research	Świerk	x
	Miscellaneous locations combined in one material balance area	Various	x
South Africa	Hot Cell Complex	Pelindaba	—
Sweden	Central storage fresh fuel	Studsvik	x
	RO	Studsvik	x
Switzerland	Fed. Inst. of Reactor Research	Würenlingen	x

**J. Non-nuclear installations**

State <sup>a</sup>	Abbreviated name of installation	Location	Subsidiary arrangements in force
Argentina	Heavy water plant	Arroyito	—
	Heavy water storage	Buenos Aires	—

<sup>a</sup> 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.

<sup>b</sup> 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.

## INFORMATION AND TECHNICAL SERVICES

### International Nuclear Information System (INIS)

494. Costa Rica, Jordan, Morocco and UNIDO joined INIS to bring membership to 78 Member States of the IAEA and 15 international member organizations.

495. In 1988, the input to the INIS database totalled 106 919 documents, the highest annual input so far. The year also set a new record for the volume of IAEA literature entered into the system, with 2231 items from the Agency. Non-conventional literature accounted for 25.7% of this input. The size of the database had reached 1 266 075 records by the end of the year.

496. Except for 0.5%, the input supplied by INIS members is in machine-readable form. Twenty-five INIS participants provided no input. Overall timeliness has also improved from 9 to 8 months, which is the best result in the more than 18 year history of INIS.

497. The INIS database was distributed in magnetic tape form to 43 Member States.

498. The INIS Clearinghouse distributed about 500 000 microfiches. The number of full microfiche subscriptions remained at 37. By the end of the year, the collection of microfiche masters numbered over 225 000 documents (300 000 microfiches).

499. The computer-output-on-microfiche (COM) system has been put into operation, producing semi-annual and annual cumulative indexes, back issues and current issues of INIS Atomindex and INIS Reference Series publications on microfiche. COM operations are significantly reducing the INIS printing costs, saving a noticeable amount from the regular budget.

500. The evaluation of the INIS database on CD-ROM (Compact Disk-Read Only Memory) was made by INIS Liaison Officers. Their feedback was thoroughly analysed and verified. The necessary changes will be made in the database design, software and user's manual. The first issue of the INIS database on CD-ROM is planned for April 1989.

501. Revised versions of "INIS: Descriptive Cataloguing Rules", "INIS: Descriptive Cataloguing Samples", "INIS: Terminology and Codes for Countries and International Organizations", "INIS: Authority List for Corporate Entries and Report Number Prefixes", "INIS: Specifications for Machine-Readable Data Exchange", "INIS: Authority List for Journal Titles" and "INIS: Thesaurus" were issued in the INIS Reference Series. A new manual entitled "INIS: Guidelines for Standardized

Entry of Corporate Bodies" was completed for publication by the end of 1988.

502. The 16th annual consultative meeting of INIS liaison officers was held in Istanbul, Turkey, and 58 Member States and international organizations participated.

503. The regional seminar for European INIS experts was held at the Fachinformationszentrum Karlsruhe (Federal Republic of Germany) in June. It was attended by 15 participants from 13 INIS members. The INIS regional training seminar for Asia and the Pacific was held in Beijing, China, in October and was attended by 17 participants from 9 INIS members and 37 observers from Chinese institutions using INIS output products.

### Agricultural Information System (AGRIS)

504. In autumn 1988 a new agreement between IAEA and FAO was signed. The new agreement is based on the previous one but has been updated with reference to technical developments and will be valid until explicitly cancelled by one of the parties.

505. In November 1988, the database reached the 1.5 million mark; 130 national and 17 international/regional organizations participate in AGRIS.

506. Some 107 000 document references were processed in 1988, 15% with abstracts. AGROVOC, the multilingual thesaurus of agricultural terminology, is being modified considerably. Hierarchies are being changed, and agricultural commodities introduced.

507. The tendency to use floppy disk as input medium continues, 39 centres send their input in this format, most of them using UNESCO's Micro CDS/ISIS database system.

508. Retrieval services continued to be provided with about 600 retrospective searches and 600 SDI profiles.

### Computer services

509. At the central computer site, utilization of the IBM 3083 computer (dedicated to Safeguards data processing) and of the IBM 3081 (shared by other users) during prime operating hours increased by 13% and 38% respectively over 87 actuals. At the beginning of 1988 a speed and memory upgrade of approximately 40% was made to both CPUs to handle the planned increase in utilization. Upgrades to the operating software were applied to allow better performance tuning in order to handle the increasing demand for on-line processing.

510. By the end of the year, approximately 1000 work stations (word processors, personal computers, local printers and terminals connected to the central com-

puter) were available in user areas – about 150 more than at the end of 1987.

511. The shared mainframe computer was connected to EARN (European Academic and Research Network) to provide external electronic mail services to the Agency Secretariat, including the staff of the International Thermonuclear Experimental Reactor (ITER) project based in Vienna.

512. Linkage to the international Global Telecommunications System of the World Meteorological Organization went into production as part of the implementation of the Agency's Nuclear Emergency Response System (ERS) for transmitting messages in the event of a significant nuclear accident.

513. As an initial step in providing improved data and physical security, a halon fire suppression system was successfully installed and tested in the main computer room areas.

514. On-line access to the Power Reactor Information System (PRIS) on the Agency's mainframe computer was successfully implemented at the Nuclear Information Centre in Prague.

515. In the application area, distributed on-line data access was implemented on a trial basis for the PRIS; software was developed to produce research reactor publications; a personal computer based system on a local area network was developed for the Department of Technical Co-operation expert post control; a publications sales invoicing system was implemented and an inquiry system and post history database was implemented in the Division of Personnel.

516. Use of office automation facilities within the Division of Technical Assistance and Co-operation has been extended to approximately 30 additional staff members.

517. During 1988, the amount of computer training provided to Agency staff increased by about 60% over 1987 levels, without any increase in the overall number of training staff.

### Library services

518. Forty-two new films were added to the VIC Library's film collection; the majority are on the peaceful uses of atomic energy and were donated by Member States. Some 304 films were lent to 92 institutions in Member States and were viewed by 3800 people.

519. The Library's publication programme resumed with the "Film Catalogue" and "Serial Titles". The VIC Library Catalogue was made available on microfiche.

Access to the documents collection was improved by the Library's on-line use of the UNBIS database, created by the United Nations Dag Hammerskjöld Library, as a major index to its documents collection.

520. Library training and tours were provided to 107 official visitors. Technical assistance was provided by the Library to the United Nations Commission on International Trade Law in the automation of their library catalogue, to the UNIDO Industrial Information Section mission in the automation of the Algerian Entreprise Nationale d'Organisation et d'Information (ENORI) library and documentation facility, and to the USSR State Public Library for Science and Technology.

521. The number of active exchange agreements with other institutions increased to 152, with the result that 519 books and 1863 serial titles were received by the Library free of cost.

522. The number of volumes in the book collection increased by 3199 to 76 929. The number of current titles in the journal collection stood at 4168 at the end of the year. The library collection of United Nations documents contains over 1 069 000 items; 45 000 of which were added during the year. Technical reports in nuclear science and engineering increased by 20 000 to over 571 000 titles.

523. The Library lent 10 204 books and over 1000 technical reports and documents from the collection of United Nations documents; 2769 reference questions were dealt with, 25 355 journal issues were circulated. Through an active interlibrary loan programme the Library borrowed 3692 books and journals for staff and responded to over 3500 requests from other libraries.

### Scientific journals

524. Twelve regular issues of "Nuclear Fusion" were published, in which the following reviews are of particular importance:

- (i) Executive summary of INTOR-Phase Two A, Part III (IAEA Workshop 1985-87) (issue 4);
- (ii) Special Topic "Progress in stellarator/heliotron research: 1981-86" by B.A. Carreras et al. (issue 9); and
- (iii) Review paper "Field reversed configurations" by M. Tuszewski (issue 11).

525. Preparations for the sixth edition of the Supplement "World Survey of Activities in Controlled Nuclear Fusion Research" have started. The material has been prepared and questionnaires sent out to contributors.

# ADMINISTRATION

## Legal Affairs

### Amendment to Article VI.A.1 of the Statute

526. 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 ten – instead of nine – Member States "most advanced in the technology of atomic energy including the production of source materials" had been accepted by 68 Member States by the end of the year. The amendment will come into force when it has been accepted by two thirds of the Member States in accordance with their respective constitutional requirements.

### Conventions relating to nuclear accidents

527. The Convention on Early Notification of a Nuclear Accident<sup>12</sup>, which entered into force on 27 October 1986, was ratified by 11 States and acceded to by 1 State and 1 international organization during 1988. Altogether, there were 72 signatories and 32 parties by the end of the year.

528. The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency<sup>13</sup>, which entered into force on 26 February 1987, was ratified by 11 States and acceded to by 1 state and 1 international organization during 1988. Altogether, there were 70 signatories and 28 parties by the end of the year.

### Physical Protection Convention

529. The Convention on Physical Protection of Nuclear Material<sup>14</sup>, which entered into force on 8 February 1987, was acceded to by 2 States during 1988. By the end of the year, 46 States and EURATOM had signed the Convention and 24 States were party to it.

### Agreements relating to liability for nuclear damage

530. The Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention deal-

ing with civil liability for nuclear damage was adopted and opened for signature at the international conference jointly organized by the OECD/NEA and the IAEA on 21 September 1988. It extends to States parties the coverage of the Paris and the Vienna Conventions and resolves potential conflicts of law which could result from the simultaneous application of the two Conventions to the same nuclear accident. By the end of the year, 20 States had signed the Joint Protocol.

531. The Vienna Convention on Civil Liability for Nuclear Damage, which entered into force on 12 November 1977, was signed by one more State during 1988. By the end of the year, there were 10 signatories and 10 parties.

532. Preparation was under way of an updated edition of Legal Series No. 3, listing agreements registered with the Agency, to be published in 1989.

### Regional Co-operative Agreement

533. By the end of the year, 14 States had notified their acceptance of the new Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (RCA) that entered into force on 12 June 1987.

### Nuclear legislation advisory services

534. Advice on nuclear legislation and regulatory activities was provided to China and to Tunisia to supplement the advice provided in 1987.

### Matters relating to nuclear safety

535. In response to a suggestion made at the thirty-first session of the General Conference, the Agency continued to compile and systematize 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 1989. On the basis of replies received from some 45 countries, the compilation will include the texts and other materials covering more than 100 agreements.

12 Reproduced in document INFCIRC/335.

13 Reproduced in document INFCIRC/336.

14 Reproduced in document INFCIRC/274/Rev. 1.



536. Preparatory work was undertaken pursuant to Resolution GC(XXXII)/RES/490, in which the General Conference requested the Director General to establish a representative technical group of experts with the objective of elaborating an internationally agreed code of practice for international transactions involving nuclear wastes.

## Finance

537. On the basis of an exchange rate of 14.20 Austrian Schillings to one United States dollar, the General Conference appropriated an amount of \$137 337 000 for the Regular Budget. This amount had to be adjusted in accordance with the adjustment formula presented in the attachment to resolution GC(XXXI)/RES/476 in order to take into account the exchange rate actually experienced during the year – 12.21 Austrian Schillings to one United States dollar.

538. The Regular Budget for 1988 at an exchange rate of 12.21 Austrian Schillings to one United States dollar amounted to \$156 182 000, of which \$146 838 000 was to be financed from contributions by Member States on the basis of the 1988 scale of assessment, \$5 366 000 from income from work for others and \$3 978 000 from other miscellaneous income.

539. The actual expenditures in 1988 amounted to \$147 078 169, resulting in an unencumbered balance of \$9 103 831.

540. The target for voluntary contributions to the Technical Assistance and Co-operation Fund in 1988 was established at \$38 million. At the end of the year, \$32 710 534 had been pledged by Member States in support of the technical assistance programme.

541. A total of \$24 748 606 was offered in extrabudgetary contributions by Member States, the United Nations and other international organizations during 1988. Of this amount, \$9 718 173 was for technical assistance projects, \$5 707 909 was for the Third World Academy of Sciences, \$3 873 647 was in support of safeguards, \$1 832 462 was for projects in the field of food and agriculture, and \$1 735 020 was in support of Funds in Trust. The remaining \$1 881 395 was in support of various other projects implemented by the Agency.

542. In addition, extrabudgetary resources amounting to \$12 624 966 were donated for the International Centre for Theoretical Physics and \$649 500 for the International Laboratory of Marine Radioactivity.

## Public Information

543. In response to high levels of interest among the public, the media and IAEA Member States, public information activities in 1988 focused on several key areas, notably international safeguards and nuclear safety and radiation protection. Two meetings with journalists were convened – one was the Journalist Encounter on IAEA safeguards and nuclear non-proliferation preceding the General Conference session in September 1988; and the other was the Journalist Seminar on radiation in perspective in December. These brought together leading international journalists and experts at the IAEA and other organizations for an exchange of views and briefings to foster greater awareness and understanding of technical subjects and the Agency's role in them.

544. A non-technical, layman's version of the IAEA Annual Report, entitled "Facts about the IAEA", was produced for the first time and distributed at the 32nd regular session of the General Conference; it will be updated regularly. Other information material, including brochures, pamphlets and press releases, was prepared and distributed in response to events and requests from the public, the media, international organizations and others. Staff of the Division also contributed commissioned articles and reports on IAEA symposia and other meetings, especially those featuring safety related topics, to technical and semi-technical magazines having a wide readership.

545. The IAEA's main worldwide circulation periodicals – the IAEA Bulletin and IAEA Newsbriefs – were produced at quarterly and monthly intervals, respectively.<sup>15</sup> In addition, another bimonthly periodical, IAEA News Features, was introduced during the year with five editions published on selected topics of interest, i.e. nuclear safety, radioactive waste management, safeguards, technical co-operation and food irradiation. The IAEA Topics, newsletter format, non-technical versions of technical documents, was also introduced.

15 In co-operation with contractors in Member States, the IAEA Bulletin is published in six languages (Chinese, English, French, Japanese, Russian and Spanish) and distributed to about 25 000 readers worldwide, including government and industry officials, journalists and scientists. IAEA Newsbriefs is published in English for the news media and the general public (about 9000 copies of each issue are distributed); abridged versions are translated and published separately in China and Japan.

**546.** In the audio-visual field, several technical and non-technical films were produced: a general introductory film "For the Benefit of Humanity", reviewing the Agency's overall activities over the past three decades, was completed and distributed to Member States; an information film on the Agency's communication system in the event of a nuclear accident was also completed and video copies were presented to the delegations to the General Conference. Assistance was provided for the production of the training films "Atoms for Animals" and the "Dosimetry Programme of the IAEA". The film on safeguards, "Headquarters Vienna", was screened in full on Soviet television and reached more than 100 million viewers. Four radio interview programmes were produced and distributed to radio stations in Member States.

**547.** More than 2000 requests and inquiries from members of the public were replied to and staff members of the Division gave lectures and briefings to nearly 70 groups of visitors.

## General Services

**548.** Close co-ordination was maintained with UNIDO and the other United Nations organizations located at the VIC on all questions relating to the cost-effective operation of the VIC complex and the use of common areas.

**549.** At the Agency's laboratories at Seibersdorf the conversion of the existing barn into laboratories and the construction of a new barn have been completed. In connection with the planned upgrading of the training facilities, the planning was completed and a detailed breakdown of the estimated cost was provided. Specifications for a new telephone exchange at Seibersdorf have been worked out and the relevant offers evaluated.

**550.** The installation of a Halon fire suppression system for the computer area was organized and the commissioning has been completed. Technical specifications, layouts and orders have been prepared for the technical installations required by the Emergency Response Unit.

**551.** Close monitoring of telecommunications cost and adaptation to new technological trends enabled to cope with the rising volume of messages and to stay within the available resources.

**552.** The documents collection of the first ten regular sessions of the General Conference (1957-1966) has been microfilmed and a computer index prepared to facilitate information retrieval. The microfilms are available to Member States as an alternative to paper copies.

**553.** An appraisal and review of archives holdings has been implemented in order to facilitate information retrieval from records of long term.

**554.** Purchases of scientific and non-scientific equipment and supplies and expenditures in connection with scientific and maintenance contracts amounted to around \$14.2 million; more than 3300 procurement actions were involved.

**555.** Assistance in finding accommodation and advice relating to housing problems were provided to staff members of the international organizations located at the VIC and persons accredited to these organizations. Over 350 lease contracts were concluded with the help of the VIC Housing Service.

**556.** The Commissary, with a range of around 6600 articles, served about 7800 households. Total sales amounted to approximately AS 283.2 million.

## Publishing and Printing Services

**557.** Almost 160 separate books or journal issues were published. The net income to the Agency from the sale of Agency publications was \$1 417 597 in 1988, compared with \$1 400 184 in 1987 and \$1 152 114 in 1986.

**558.** 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. The income from work for other organizations was \$1.68 million in 1988, compared with \$1.55 million in 1987.

**559.** The output of the Common Printing Service was 216 million page impressions in 1988, compared with 199 million in 1987.

## Personnel

**560.** At the end of 1988, the number of members of the Secretariat was 2079 – 797 in the Professional and higher categories, 1150 in the General Service category

and 132 in the Maintenance and Operatives Service category<sup>16</sup>.

561. Among the 608 staff members in posts subject to geographical distribution, 77 nationalities were represented.

562. The fifth traineeship programme for graduates and junior professionals from developing areas, which began in February 1988, was completed in December 1988. Twelve trainees participated.

563. As a result of improvements in recruitment procedures introduced in 1985, vacancies as a percentage of total person-months represented by established posts were further reduced – to 5.76% (in 1987 the figure was 6.77%).

564. The percentage of female staff in posts subject to geographical distribution was, on 31 December 1988, 11.18%. The percentages of female applicants and of female recruits in the Professional and higher categories were at the same level.

565. A comprehensive programme of short training workshops for middle and senior managers designed in 1987 was implemented and 138 staff attended.

566. A computer link with the Central Secretariat of the United Nations Joint Staff Pension Fund (UNJSPF) was installed to enable the transfer of monthly payroll data for pensioners living in Austria and thus ensure the timely payment of pension benefits to beneficiaries.

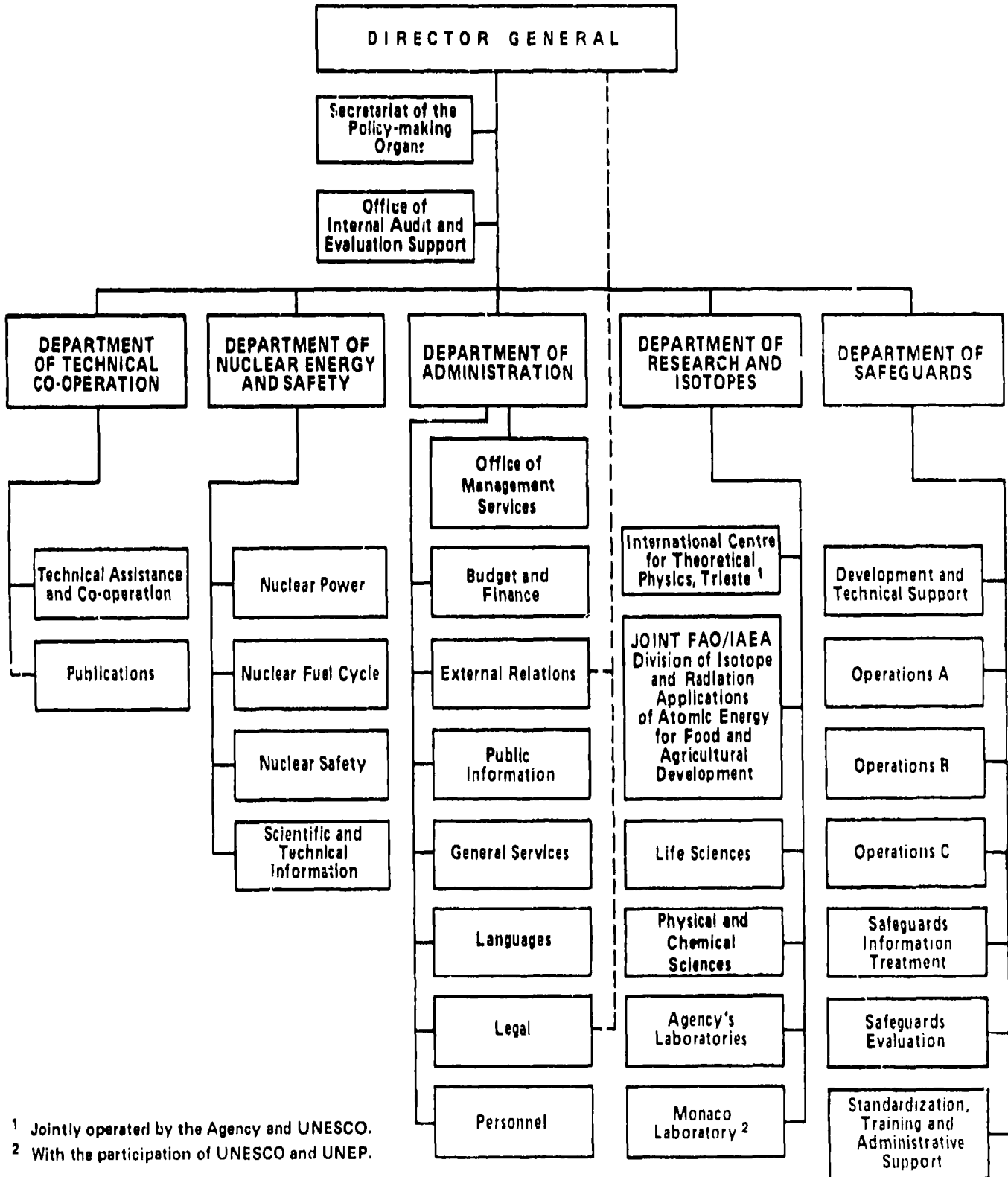
567. The Secretariat continued to participate in the work of United Nations common system bodies – for example, the International Civil Service Commission (ICSC), the Consultative Committee on Administrative Questions (CCAQ) and the United Nations Joint Staff Pension Board (UNJSPB).

568. The following organizational chart shows the structure of the Secretariat.

16 These figures represent: members of the Secretariat occupying manning table posts (1622) or charged to manning table posts (92) or to the temporary assistance fund (103), officials serving on reimbursement basis (194) or on secondment (4), and Commissary staff (64)

# ORGANIZATIONAL CHART

(as of 31 December 1988)



<sup>1</sup> Jointly operated by the Agency and UNESCO.

<sup>2</sup> With the participation of UNESCO and UNEP.