

# THE ANNUAL REPORT FOR 1977

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INTERNATIONAL ATOMIC ENERGY AGENCY



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List of abbreviations

Agency	International Atomic Energy Agency
AGRIS	Agricultural Information System
EURATOM	European Atomic Energy Community
FAO	Food and Agriculture Organization of the United Nations
IAEA	International Atomic Energy Agency
IIASA	International Institute for Applied Systems Analysis
INIS	International Nuclear Information System
IOC	Intergovernmental Oceanographic Commission
MHD	Magnetohydrodynamics
MIT	Massachusetts Institute of Technology
NEA	Nuclear Energy Agency of the Organisation for Economic Co-operation and Development
NPT	Treaty on the Non-Proliferation of Nuclear Weapons (reproduced in document INFCIRC/140)
OECD	Organisation for Economic Co-operation and Development
PNE	Nuclear explosions for peaceful purposes
SIDA	Swedish International Development Authority
Tlatelolco Treaty	Treaty for the Prohibition of Nuclear Weapons in Latin America
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
WHO	World Health Organization
WMO	World Meteorological Organization

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NOTE

All sums of money are expressed in United States dollars.

## INTRODUCTION

1. The year 1977 presented a mixed picture for the nuclear power industry. New orders amounting to 12 plants with a total capacity of 13 500 MW were placed compared with ten and 11 000 MW during the preceding year. On the other hand, 206 plants having a total capacity of about 95 000 MW were in operation by the end of the year, providing 20% or more of the electricity generated in some countries and achieving load factors up to 90% and proving their worth, particularly those in northern United States of America and Europe, during the harsh winters that ushered the year in and out, when they registered excellent performance and proved the value of independence from outside fuel supply. Moreover, these 206 nuclear power plants had accumulated more than 1500 reactor years of operating experience by the end of 1977 without a single radiation-induced fatality or even a serious radiation-induced accident. This outstanding safety record continues to receive little or no publicity in the popular press, although the most insignificant leakage or mishap is certain to give rise to headlines around the world.

2. Also in 1977 two further experimental fast breeder reactors (FBR) - JOYO in Japan and KNK-II in the Federal Republic of Germany - were commissioned. These countries thus demonstrated that they share with France, the Soviet Union and the United Kingdom the role of pioneers in the development of FBR technology. The encouraging experience which France has had with the Phénix, particularly with fuel element performance at very high burn-up, augurs well for the success of the world's first commercial fast breeder, Super-Phénix, which is now under construction and expected to be in operation by 1983.

3. Several important developments in the nuclear fuel cycle took place in 1977. The first batch of oxide fuel was reprocessed at the "COGEMA" commercial plant in La Hague, France, in the middle of the year. The capacity of La Hague is expected to reach 400 tons/year by 1982-84, 1200 tons/year by 1985 and 2000 tons/year by 1988-89.

4. In the United Kingdom a public enquiry on the advisability of constructing a commercial oxide fuel reprocessing plant at Windscale was conducted by Justice Parker as Inspector.[1]

5. It is expected that the first cascade of the enrichment plant of "EURODIF" at Tricastin, France, will operate by the end of 1978 and that commercial production will rise to the final target of 10.8 million SWUs by 1982. The construction of the gaseous diffusion enrichment plant "COREDIF" was approved in principle in 1977; the construction time-table will be determined in the light of the market for enrichment services.

6. The commercial record of the present generation of nuclear power plants has also continued to be good. In all major industrial countries in which nuclear power plants are operating, they are generating electricity at total costs which are competitive with or considerably lower than fossil-fired plants of similar size.

7. The Agency's International Conference on Nuclear Power and its Fuel Cycle at Salzburg in May 1977 provided a timely opportunity for a comprehensive review of the prospects of nuclear energy and the problems of the fuel cycle. The Salzburg Conference was the major event marking the twentieth anniversary of the Agency which was also celebrated at its General Conference in September.

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[1] Early in 1978 Justice Parker recommended that construction should proceed and in May 1978 the House of Commons approved plans for a plant with a throughput of 1200 tons of oxide fuel per year. Construction is expected to start in 1981-82 and the plant to be operational by 1987.

8. The Conference, which attracted more than 2000 participants, reviewed the overall role to be played by nuclear energy in relation to alternative energy sources, giving particular attention to the problems of the entire nuclear fuel cycle and its integration. From the discussions at Salzburg there emerged a general reaffirmation that nuclear power is a necessary and irreplaceable source of energy for mankind both in the short and longer term. There was also a consensus at Salzburg that in due course it would be imperative to develop nuclear plants (together with the supporting fuel cycle) that would permit a fuller use of energy content of fissile materials. Most of the leading industrial countries consider that the plutonium breeder offers the only technologically mature alternative to the use of the single remaining source of fossil fuel that would be available in the next century - coal.

9. These views were generally reaffirmed at the tenth session of the World Energy Conference held at Istanbul, Turkey, in September 1977 and have since been echoed by the International Energy Agency and the Commission of the European Communities. For many developing countries which have no early alternative to oil as their main source of electric as well as automotive energy, it is becoming clearly essential to reduce the pressure of the industrialized world on limited oil reserves.

10. The last quarter of the year also saw the launching in Washington of the two-year International Nuclear Fuel Cycle Evaluation (INFCE) which is intended by its sponsors to evaluate means for developing and operating the nuclear fuel cycle in ways that minimize the risks of nuclear proliferation. Most of INFCE's meetings are taking place at the Agency's Headquarters, and the Agency is also providing certain other technical and administrative support. One of the chief factors that led to INFCE was concern lest the continued development of the plutonium fast breeder might promote the further spread of nuclear weapons.

11. Beside the papers presented to and the discussions at these intergovernmental conferences, 1977 saw a marked increase in the number of national and international evaluative studies covering the entire nuclear fuel cycle or major parts of it. Whether government-sponsored or private, these reports provided much of the policy-oriented information on which national leaders based their decisions.

12. Among the studies issued in the United States were the American Physical Society's Nuclear Fuel Cycles and Waste Management, the Ford Foundation's Nuclear Power Issues and Choices, and M.I.T.'s Energy: Global Prospects 1985-1995. The Energy Research and Development Administration of the United States also issued a Report on Light Water Reactor Fuel Reprocessing and Recycling. Government reports issued by other countries include: Canada's Hare Report (The Management of Canada's Nuclear Waste), Australia's Ranger Uranium Environmental Inquiry - Second Report, Sweden's Handling of Spent Nuclear Fuel and Final Storage of Vitrified High Level Reprocessing Waste, the United Kingdom's Nuclear Power and the Environment (sixth report of the Royal Commission on Environmental Pollution, also known as the "Flowers" Report) and the Report on Peaceful Use of Nuclear Energy, published by the Federal Ministry for Research and Technology of the Federal Republic of Germany, 1977. The final report of the Windscale inquiry was issued in early 1978. International organizations also conducted numerous studies. The OECD published reports on the World Energy Outlook, Reprocessing of Spent Nuclear Fuels in OECD Countries, and NEA in co-operation with the IAEA, Uranium: Resources, Production and Demand. NEA also issued a Report on Objectives, Concepts and Strategies for the Management of Radioactive Waste Arising from Nuclear Power Programmes. In addition, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) issued its detailed biannual report, on the Sources and Effects of Ionizing Radiation.

13. The wish to stem further weapons proliferation was reflected in changes in nuclear export policy. In varying degrees, all the major nuclear exporters have imposed additional conditions on the transfer of materials, plant and technology, the minimum consensus being reflected in guidelines which 15 Member States communicated to the Agency early in 1978. This has caused some apprehension lest such restrictions should hamper the nuclear energy development of importing countries.

14. The major steps in 1977 towards a world-wide non-proliferation regime were the entry into force of the NPT Safeguards Agreement between the Agency, EURATOM and the seven non-nuclear-weapon States of the Community on 21 February 1977 and of that with Japan on 2 December 1977. Negotiation of the subsidiary arrangements under these agreements was proceeding at the end of the year. At year's end, there were 102 parties to NPT, including three nuclear-weapon States. NPT membership thus encompassed nearly all the major industrial countries of the world. Thirteen non-nuclear-weapon States having nuclear activities or plant remained outside NPT. In eight of these, according to information available to the Agency, Agency safeguards were in application at all significant nuclear facilities. In five other non-nuclear-weapon States, there were facilities unsafeguarded by IAEA; in three of them, the unsafeguarded plant was significant from the point of view of producing weapons-grade material.

15. During the year, Panama, Portugal and Switzerland acceded to the Treaty, and six additional NPT safeguards agreements came into force.

16. The Board also approved a safeguards agreement with India, specifically covering the supply of heavy water, and a safeguards agreement with Pakistan, specifically covering the supply of uranium concentrates (yellow cake). The heavy water and yellow cake will be provided by the Soviet Union and Niger respectively. Two agreements were concluded with Argentina. One covers a fuel fabrication plant supplied by the Federal Republic of Germany, the other covers supplies in connection with a co-operation agreement between Argentina and Canada. In addition an agreement covering a research reactor and its fuel was concluded with the Democratic People's Republic of Korea.

17. The Board also considered the first Special Safeguards Implementation Report (SSIR), which analyses in detail the results and effectiveness of Agency safeguards. The report, which covered the year 1976, concluded that in none of the 40 States in which inspections were carried out was there any diversion of a significant quantity of safeguarded nuclear material and recorded the Secretariat's confidence that in these States there was no diversion at all.

18. At the Salzburg Conference, the Secretariat presented the Agency's Study on Regional Nuclear Fuel Cycle Centres. Although no specific proposals for the establishment of such a centre have yet emerged, it is understood that the concept is under consideration by the Commission of the European Communities, and there have been informal discussions with a Western European utilities group (OPEN) on this subject. A number of Governments have also continued to show interest in the question of international plutonium and spent fuel management. Both topics will be considered by INFCE.

19. In October, the representatives of 40 Governments met at the Agency to begin the preparation of an international agreement against theft, sabotage and forcible seizure of nuclear material - a "Convention on the Physical Protection of Nuclear Material", a matter which the General Conference had addressed in Resolution GC(XXI)/RES/350.

20. In its work to help developing countries to introduce nuclear power the Agency held four major training courses during 1977, one in France, one in the Federal Republic of Germany and two in the United States of America.

21. In 1972, the Agency concluded a Regional Co-operative Agreement with Member States in Asia and the Pacific to further research, development and training related to nuclear science and technology. Within this framework, participating countries are carrying out programmes in food irradiation and other food and agricultural as well as medical and industrial applications of nuclear techniques and environmental research. The programmes are designed to yield direct economic and social benefits to the region. In June 1977, the Board approved a further five-year extension of the Regional Co-operative Agreement, and the following Member States have to far agreed to this extension: Australia, India, Indonesia, Malaysia, Pakistan, Singapore and Thailand.

22. It is hoped that the remaining 11 original parties will also accept the extended agreement; they comprise Bangladesh, the Republic of Korea, the Philippines, Sri Lanka and Viet Nam. The Japanese Government is also considering accession.

23. The number of irradiated food items that Member States have approved for human consumption has now reached twenty-six. They include potatoes, onions, grain and grain products as well as meat and fish. Together with the Government of the Netherlands the Agency is considering the setting up of a demonstration project which would provide information about the commercial and technical aspects of food irradiation.

24. In June 1977, Nigeria and the Agency signed an agreement for a large-scale project for controlling the tsetse fly - the vector of sleeping sickness - by means of the "sterile male technique".

#### Matters of special interest to the General Assembly of the United Nations

25. At its session in autumn 1977, the General Assembly discussed the Agency's work and its report in greater detail than usual and adopted several resolutions, relating directly to the Agency, most of its programmes and its structure (Resolutions 32/6, 32/49, 32/50, 32/81 and 32/87.F). Almost every chapter in the present report as well as the Introduction contains information which is directly relevant to the resolutions adopted by the General Assembly which paid particular attention to the strengthening of the safeguards and technical assistance programmes of the Agency, the universal adherence to NPT, the responsibility of the nuclear-weapon States under Article VI of that Treaty, the discovery and development of additional uranium resources and the assurance of satisfactory arrangements for the supply of nuclear fuel, facilities and technology, the need for a convention on the physical protection of nuclear materials, the creation of regional nuclear fuel cycle centres and of an international plutonium management scheme and the continued study of the peaceful uses of nuclear explosives and their economic and non-proliferation implications. One of the resolutions also asked the Agency to give due consideration to the request of developing countries for an increase in their representation on the Board. Another called for the denuclearization of Africa and appealed to all States to refrain from any co-operation with South Africa in the nuclear field; others urged the establishment of nuclear-weapon-free zones in the Middle East and South Asia.

26. At its meeting in June 1977, the Board designated Egypt by majority vote as the Member State in Africa most advanced in the technology of atomic energy, including the production of source materials. South Africa had hitherto been designated for this seat.

27. Nicaragua rejoined the Agency on 25 March 1977. It had previously withdrawn from the Agency on 14 December 1970.

#### Administrative questions

28. The continuing decline of the exchange rate of the US dollar in terms of Austrian schillings has increased the financial difficulties of the Agency at a time when the calls on it for the expansion of its programmes have been growing rapidly. As a result, the Agency has continued to apply stringent economy measures, particularly in areas such as travel and recruitment.

29. According to information provided by the Austrian Government, the Agency's Permanent Headquarters at the Donaupark will become available for occupation in mid-1979. Plans are being made to transfer operations to the new headquarters about that time. The latest projections indicate that the Agency will require both of the office "towers" initially assigned to it.

## THE AGENCY'S ACTIVITIES

### TECHNICAL ASSISTANCE AND TRAINING

#### Resources available for technical assistance

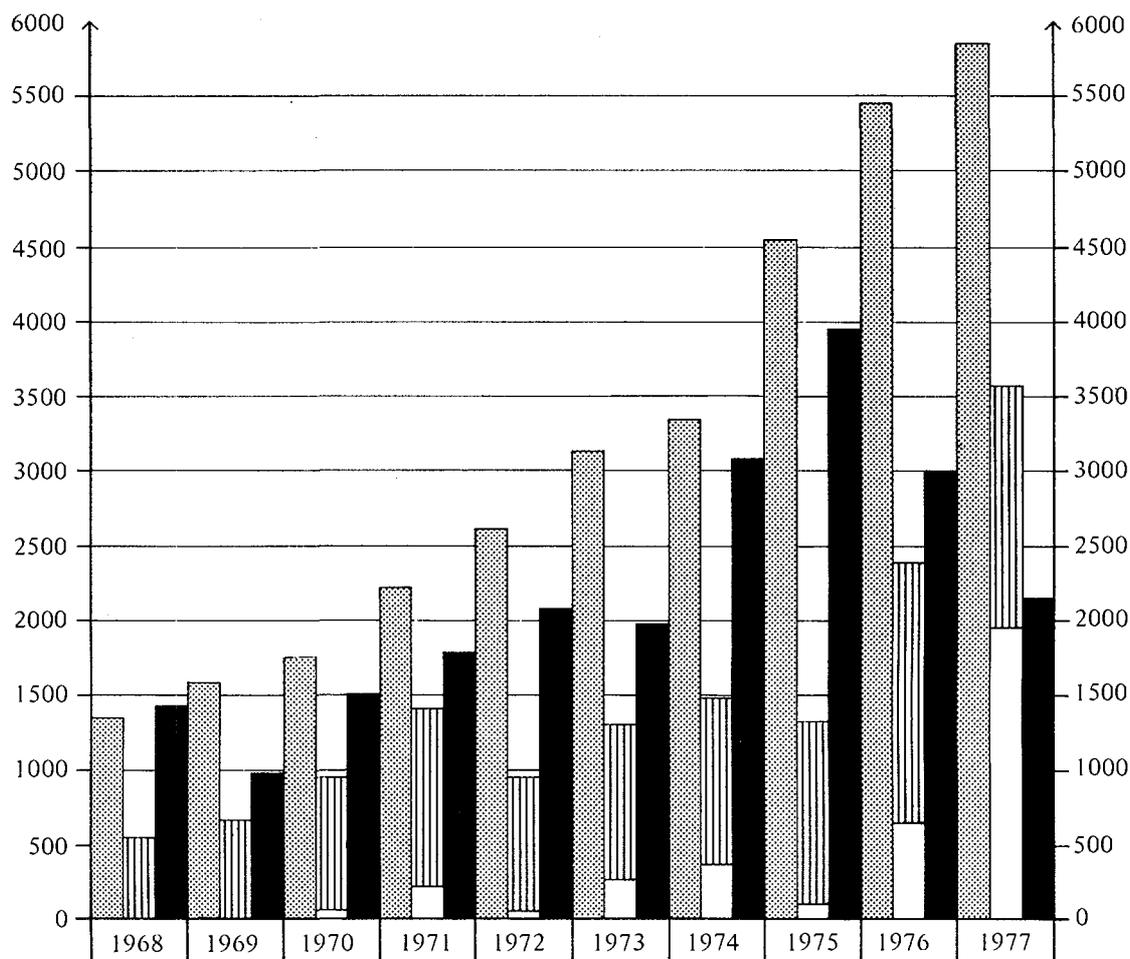
30. The resources that were made available to the Agency for carrying out technical assistance programmes during the period 1968 to 1977 are shown in Figure 1. Resources available in 1977 amounted to \$11.6 million compared with about \$10.9 million in 1976. The main increase was in extrabudgetary funds which amounted to \$1.94 million in 1977 compared with \$0.66 million in 1976. Resources in cash from voluntary contributions and miscellaneous income for the Agency's own or "regular programme" increased by \$0.4 million. On the other hand, the net resources available from UNDP decreased by nearly \$0.9 million.

31. The main source of funds for the Agency's regular programme is of course the voluntary contributions of Member States to the General Fund. The target for such contributions in 1977 was \$6 million. At the end of the year, pledges had reached 88.9% of the target. In 1976 when the target was \$5.5 million, pledges reached 92%. The amount pledged in 1977 was \$5 334 600 compared with \$5 062 000 in 1976. Table 1 shows the status of voluntary contributions to the General Fund for the years 1968-1977.

Table 1  
Voluntary contributions: 1968-1977

Year	Established target (in millions of dollars)	Voluntary contributions pledged to the General Fund				
		Amount \$	Percentage of target	Shortfall or (overrun) \$	Number of Members pledging	Percentage of Members pledging
1968	2.0	1 423 557	71.2	576 443	63 of 99	63.6
1969	2.0	1 488 426	74.4	511 574	68 of 102	66.7
1970	2.0	1 672 933	83.6	327 067	74 of 103	70.9
1971	2.5	2 142 675	85.7	357 325	71 of 102	69.6
1972	3.0	2 485 405	82.8	514 595	71 of 102	69.6
1973	3.0	2 847 012	94.9	152 988	70 of 104	67.3
1974	3.0	3 083 261	102.8	(83 261)	65 of 105	61.9
1975	4.5	4 219 391	93.8	280 609	75 of 106	70.8
1976	5.5	5 061 957	92.0	438 043	72 of 109	66.0
1977	6.0	5 334 637	88.9	665 363	68 of 110	61.8

**FIGURE 1**  
**RESOURCES AVAILABLE FOR**  
**AGENCY TECHNICAL ASSISTANCE PROGRAMMES: 1968-1977**  
(in thousands of dollars)



Agency funds	1348	1586	1749	2224	2636	3124	3348	4540	5474	5866
Extrabudgetary funds	—	13	61	218	60	267	369	108	661	1944
Assistance in kind	565	658	894	1197	900	1032	1114	1212	1735	1632
UNDP funds	1422	981	1513	1775	2072	1964	3082	3941	3002	2144
<b>TOTAL</b>	<b>3335</b>	<b>3238</b>	<b>4217</b>	<b>5414</b>	<b>5668</b>	<b>6387</b>	<b>7913</b>	<b>9801</b>	<b>10872</b>	<b>11586</b>

Agency funds
 Extrabudgetary funds
 Assistance in kind
 UNDP funds

32. The increase in resources in 1977 in the form of extrabudgetary funds was due mainly to the special cash contribution of about \$100 000 from the Government of Canada and to the special cash contribution of \$1.2 million from the Government of the United States of America, which made it possible to meet all of the requests that had been approved under the Agency's regular programme in 1977 but that could not be met because of insufficient Agency funds. The new funds received in 1977 from the Swedish International Development Agency (SIDA), amounted to \$619 700 compared with \$637 900 in 1976.

33. The decline of nearly 29% in UNDP funds was due chiefly to the phasing out and completion of UNDP financed assistance for a number of individual projects in 1977 and to the postponement of the starting date of certain new projects. This was the second consecutive decrease but it is expected that the volume of UNDP assistance will rise again during the next 2-3 years.

#### The technical assistance provided

34. The total value of funds and resources "in kind" allocated for technical assistance rose from \$13.7 million in 1976 to more than \$15.3 million in 1977. Of these, \$9 018 000 were actually spent and \$6 356 200 were allocated to approved projects in respect of which Agency implementation had begun but obligated funds had not yet been spent. The latter sum comprised unliquidated obligations amounting to \$4.9 million and assistance "in kind" valued at about \$1.5 million. The total monetary value of the assistance actually given was in fact slightly higher than in 1976, by \$673 400 or about 8%.

35. The unliquidated obligations and assistance in kind that were outstanding at 31 December 1977 comprised:

- \$ 741 000 for expert services;
- \$2 651 600 for equipment and supplies; and
- \$2 963 600 for fellowships.

#### The long-term trend

36. Table 2 shows the monetary value of the technical assistance provided by the Agency from all sources during the period 1970 to 1977.

Table 2  
Agency technical assistance by source: 1970-1977  
(in US dollars)

Year	UNDP funds	Agency funds	Extrabudgetary funds	Assistance in kind	Total
1970	1 469 200	1 619 300	75 500	819 100	3 983 100
1971	1 838 800	2 124 600	60 000	921 700	4 945 100
1972	2 072 000	2 556 000	85 700	779 000	5 492 700
1973	1 964 300	2 675 900	87 100	1 039 400	5 766 700
1974	3 081 600	2 413 200	170 300	1 077 400	6 742 500
1975	3 941 500	3 423 500	252 900	942 300	8 560 200
1976	3 002 300	3 954 700	358 800	1 021 500	8 337 300
1977	2 144 400	4 997 100	592 200	1 284 300	9 018 000

37. The distribution of technical assistance according to type of assistance (experts, equipment and fellowships) during the last two years and during the decade 1968-1977 was as follows:

Type	1976		1977		1968-1977	
	%	\$1000	%	\$1000	%	\$1000
Experts	34.5	2878.9	36.2	3265.4	34.6	20 505.4
Equipment	34.9	2910.7	33.8	3048.7	34.7	20 551.9
Fellowships	30.6	2547.7	30.0	2703.9	30.7	18 156.3
Total	100.0	8337.3	100.0	9018.0	100.0	59 213.6

It is interesting to note that the percentage distribution of funds between the three types of assistance in 1976 was almost identical with the ten-year averages.

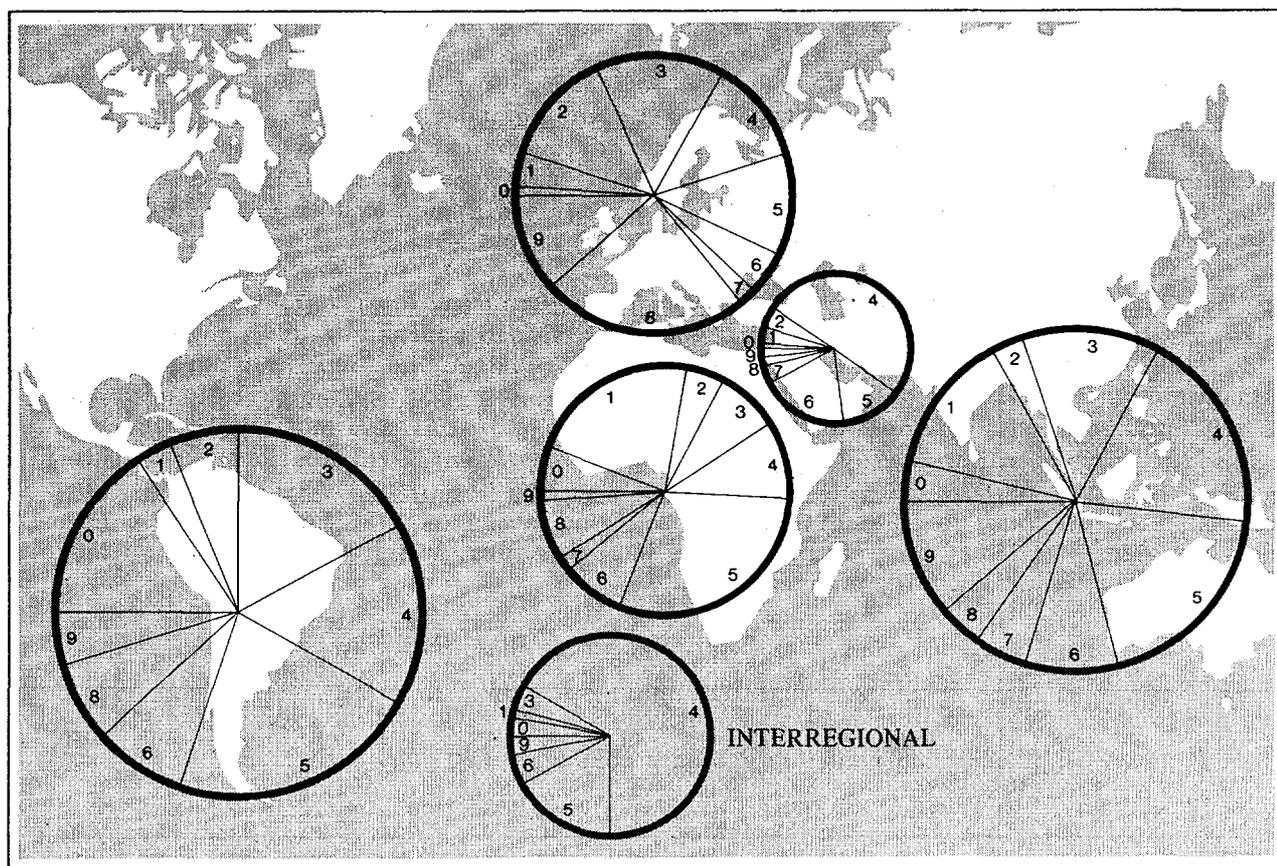
#### The 1977 programme

38. Table 3 provides a comparison of the amount of assistance given in 1976 and 1977 in the five leading fields of the ten fields of the Agency's technical assistance activities.

Table 3  
Assistance by field of activity and type: 1976 and 1977  
(in thousands of dollars)

Field of activity	Year	Experts	Equip- ment	Fellow- ships	Share of total programme	
		\$	\$	\$	\$	%
Nuclear engineering and technology	1976	436.4	304.6	792.8	1533.8	18.4
	1977	508.2	573.1	891.4	1972.7	21.9
Application of isotopes and radiation in agriculture	1976	541.9	626.8	520.1	1688.8	20.3
	1977	727.5	525.9	529.0	1782.4	19.8
Prospecting, mining and processing of nuclear materials	1976	836.5	365.7	127.2	1329.4	15.9
	1977	696.0	239.2	155.7	1090.9	12.1
Nuclear physics	1976	131.4	192.6	291.1	615.1	7.4
	1977	313.2	250.9	194.5	758.6	8.4
Application of isotopes and radiation in industry and hydrology	1976	181.5	619.6	91.0	892.1	10.7
	1977	173.3	525.6	52.2	751.1	8.3
Total	1976	2127.7	2109.3	1822.2	6059.2	72.7
	1977	2418.2	2114.7	1822.8	6355.7	70.5
Total assistance	1976	2878.9	2910.7	2547.7	8337.3	100.0
	1977	3265.4	3048.7	2703.9	9018.0	100.0

**FIGURE 2**  
**DISTRIBUTION OF TECHNICAL ASSISTANCE BY FIELD AND REGION: 1977 <sup>a/</sup>**



**SUMMARY**

Field of activity	Africa %	Asia and the Pacific %	Europe %	Latin America %	Middle East %	Inter- regional %	All regions %	
0 - General atomic energy development	6	4	1	16	1	3	7	
1 - Nuclear physics	22	13	4	3	4	1	8	
2 - Nuclear chemistry	5	3	13	6	4	—	6	
3 - Prospecting, mining and processing of nuclear materials	8	13	15	17	—	4	12	
4 - Nuclear engineering and technology	10	19	12	16	51	67	22	
Application of isotopes and radiation in	5 - Agriculture	30	19	12	22	13	17	20
	6 - Medicine	8	9	5	8	19	5	8
	7 - Biology	2	5	2	—	4	—	2
	8 - Industry and Hydrology	8	4	24	7	2	—	8
9 - Safety in nuclear energy	1	11	12	5	2	3	7	
	100%	100%	100%	100%	100%	100%	100%	

<sup>a/</sup> For each region, the relative monetary value of the technical assistance provided by the Agency is denoted by the size of the circle superimposed over the region on the map. The size of the segments in each circle indicates the share of total assistance given in the various fields of activity.

39. The relative importance in 1977 of each of the ten fields of activity is shown in Figure 2 by region and for all regions. It will be seen that for countries in the regions of Africa, Latin America and Asia and the Pacific, the share taken by agriculture was above the average. However, more technical assistance was provided in the field "nuclear engineering and technology" to countries in the Middle East and overall (see Table 3) than in any other field. In interregional activities the field "nuclear engineering and technology" predominated because of the training courses held in France, the Federal Republic of Germany and the United States of America on nuclear power plant construction and operation management, a course on nuclear power project planning and a course emphasizing manpower development for nuclear power projects. For the fourth successive year, "prospecting, mining and processing of nuclear materials" took the third largest share of resources; this was largely due to the UNDP-financed assistance to uranium prospecting projects in Bangladesh, Chile, Greece, Pakistan, Peru and Turkey.

40. Table 4 provides more information about the regional and interregional training courses and study tours organized by the Agency. Eighteen courses or tours were held in all in 1977 and 16 countries served as hosts. Four hundred and forty-four persons from 54 countries and a regional organization took part; the cost of 364 of the participants was borne by project funds; the cost of the remaining 80 participants was borne by another organization or programme or by the participant's Government. The cost of three training courses was met by SIDA; only one such project was assisted by UNDP in 1977. Nuclear power was the predominant subject in 1977, having attracted about 38% of all participants in such projects, followed by training courses in agriculture, which were attended by 25% of all participants in intercountry projects.

Table 4  
Intercountry projects conducted in 1977

Project title	Place and dates	Total number of participants	Source of funds
Interregional training course on nuclear power plant construction and operation management (Phase II)	Argonne, Illinois 18 January to 29 April	35	Regular programme
Interregional training course on the use of nuclear techniques for the study of chemical residue and pollution problems	Colombo, Sri Lanka 1 to 29 March	26	SIDA
Interregional training course on nuclear power plant construction and operation management (Phase II)	Saclay, France 29 March to 8 July	17	Regular programme
Interregional training course on the use, design and maintenance of nuclear and related electronic equipment	Turin, Italy 18 April to 15 July	18	Regular programme

Project title	Place and dates	Total number of participants	Source of funds
Regional workshop on nuclear law	Rio de Janeiro, Brazil 27 June to 1 July	28	Regular programme
Interregional training course on the use of nuclear techniques in animal production	Lima, Peru 27 June to 22 July	22	SIDA
Interregional training course on the use of isotopes and radiation in entomology with special reference to pest management and the sterile-insect technique	Gainesville, Florida 11 July to 19 August	18	Regular programme and Government of the United States of America
Interregional training course on occupational and environmental safety in the utilization of radioactive material	Boston, Massachusetts 11 July to 5 August	21	Regular programme and Government of the United States of America
Interregional training course on the preparation, control and utilization of radiopharmaceuticals	Los Angeles, California 18 July to 12 August	20	Regular programme and Government of the United States of America
Interregional training course on the application of nuclear techniques in agriculture	Moscow, Soviet Union 1 September to 1 December	25	Regular programme
Interregional training course on uranium geochemical prospecting methods	Skofja Loka, Yugoslavia 5 to 30 September	24	Regular programme
Interregional training course on nuclear power plant construction and operation management (Phase II)	Karlsruhe, Federal Republic of Germany 5 September to 25 November	39	Regular programme
Interregional training course on nuclear power project planning and implementation (Phase I)	Argonne, Illinois 7 September to 16 December	36	Regular programme

Project title	Place and dates	Total number of participants	Source of funds
Interregional training course on the design, use and maintenance of nuclear medical equipment	London, United Kingdom 12 September to 16 December	16	Regular programme
Study tour on the technical aspects of safeguards and the control of nuclear material	Austria, Czechoslovakia, German Democratic Republic and the Soviet Union 12 September to 11 October	18	Regular programme
Regional training course on nuclear laboratory technicians' training	Kuala Lumpur, Malaysia 10 October to 2 December	24	Regular programme
Regional training course on the economic and technical aspects of nuclear power with emphasis on manpower development	Seoul, Korea, Republic of 5 to 16 December	36	UNDP
Interregional training course on plant breeding for disease resistance, including the utilization of induced mutation techniques	New Delhi, India 14 November to 13 December	20	SIDA

41. On behalf of UNDP the Agency provided large-scale assistance (\$1 881 700) in 1977 to 18 projects and small-scale assistance (\$262 700) to 25 projects. These 43 projects include four new projects for which UNDP large-scale assistance totalling \$6 million was approved for provision over the period 1977-1981 and five new projects involving UNDP small-scale assistance amounting to \$239 000 during 1977-1978.

42. The new UNDP large-scale assistance projects are: Nuclear manpower qualification and training, in Brazil; Nuclear power plant, in Chile; Use of nuclear techniques in animal production, in Nigeria; and, Nuclear energy, in Peru.

43. The purpose of the project in Chile is the creation of the foundations for the human and technical infrastructure needed for the implementation of the national nuclear power programme, whereas the project in Peru embraces five activities: (i) the introduction of nuclear power; (ii) the evaluation and development of uranium resources; (iii) the application of nuclear techniques in agriculture; (iv) radiation protection and nuclear safety; and (v) project co-ordination and administration. In last year's report[2] it was incorrectly reported that UNDP assistance to the project, Exploration for uranium in the Siwalik Sandstones, in Pakistan, had been completed; this project is still active.

44. UNDP large-scale assistance to the project, Exploration for uranium in Central and Eastern Macedonia and Thrace, in Greece, was completed in 1977. UNDP assistance was provided in two phases. Whereas the objectives of phase I included the systematic low-density survey of the project area (28 400 km<sup>2</sup>) and the training of national personnel, during

[2] See document GC(XXI)/580, para. 32.

phase II emphasis was given to medium-density and detailed exploration of areas identified during the reconnaissance phase as favourable to uranium mineralization. In-service and fellowship training, provided throughout the duration of the project, and the geological/radiometric information obtained were the most important project achievements. Certain anomalies have been identified during the work of the project which would require further investigation and economic evaluation, and the Greek authorities are continuing with this work.

#### The Agency's regular programme

45. The concern about the increase during the past few years in the amount of unobligated funds in respect of the regular programme led to the convening in August 1977 of a Group of Experts to advise on the implementation of the Agency's technical assistance programme. The Expert Group made a number of recommendations, and action has been taken and continues to be taken on the recommendations addressed to the Agency:

- (a) Steps are being taken to stimulate the identification of sound projects calling for the provision of larger amounts of assistance than at present and over a number of years;
- (b) On the invitation of the Director General, 37 countries have appointed liaison officers as a means of improving communications between the Agency and Governments on day-to-day matters relating to technical assistance;
- (c) Preparations started during 1977 for programming missions to be carried out in 1978 to assist Governments in the formulation of requests;
- (d) With regard to the implementation of technical assistance, the tasks and responsibilities of the Agency staff concerned have been defined in internal briefing notes on the subject;
- (e) New methods for programme monitoring and planning were introduced, and an implementation report on the progress made in providing approved regular programme assistance was prepared and will henceforth be submitted annually to the Technical Assistance Committee of the Board of Governors;
- (f) Alternative means of expert recruitment and equipment procurement were studied; the best of these will be introduced in 1978; and
- (g) A new draft revision of the Guiding Principles and General Operating Rules to Govern the Provision of Technical Assistance by the Agency was published in which some other recommendations made by the Expert Group are reflected.

46. A review of regular programme implementation made at the end of 1977 revealed that the volume of the assistance being provided (expenditures and unliquidated obligations) was more than \$1.8 million higher than in 1976. When the total of the available unobligated funds equals the estimated cost of the approved assistance which has not yet been provided, the programme balances out financially. At the end of 1976 the funds needed to carry out the remainder of the approved assistance amounted to \$4 134 000, which exceeded the available funds by \$212 000. The current review indicated that the funds needed to implement the remainder of the approved assistance had decreased to \$4 010 000, whereas the programme deficit was reduced from \$212 000 to \$24 000. This shows that good progress is being made in accelerating the implementation of regular programme assistance.

47. The data given above for 1977 do not include the \$1.1 million in extrabudgetary funds received in the form of special cash contributions from the Government of Canada and the United States of America to provide assistance approved under the regular programme for 1977. (As almost all of this money was received in August, only 43% could be spent or obligated by the end of the year.)

48. An analysis of the \$4 010 000 needed to carry out approved projects in 1977 showed that \$3 448 000 would be needed in convertible currencies and assistance estimated to cost \$562 000 could be provided by using certain non-convertible currencies. The unobligated funds, however, consisted of \$2 092 000 in convertible currencies and \$1 894 000 in these non-convertible currencies. On 31 December 1977 there was thus a shortfall of \$1 356 000 in convertible currencies and a balance of \$1 332 000 in certain non-convertible currencies that could not be used to carry out approved projects.

49. This problem will probably become yet more serious in 1978. Only a small share of the approved programme can be provided by using the accumulated non-convertible currencies. A further \$1 million of voluntary contributions received in these non-convertible currencies in 1978 can probably not be used to match the assistance requested and approved by the Board. By the end of 1978 the unobligated holdings in these currencies are therefore likely to rise by \$1 million to a total of \$2.3 million.

50. Since the Agency's regular programme is based on the requests of its Member States the possibilities of making full use of these non-convertible currencies are largely beyond the control of the Agency. While every effort is being made to identify suitable projects for the non-convertible funds to be used, it should not be assumed that the programming procedures currently used by the Agency will provide a satisfactory solution. Hence it is expected that in 1978 it will be necessary to take steps to prevent a liquidity crisis, for instance by limiting the value of assistance to be provided in the 1979 programme to not more than the income likely to be received in convertible currencies. The separate report[3] on the Provision of Technical Assistance by the Agency, with Special Reference to 1977 examines these problems in greater detail.

#### Observations and conclusions

51. The increase in technical assistance expenditures in 1977 was the largest in the history of the regular programme and for the first time in many years the total of unobligated earmarkings did not rise any further. The trend of an increasing backlog in the provision of approved assistance which has been of great concern in the past few years seems therefore to have been arrested during 1977. It is too early to judge whether this trend has been reversed; if so, this will cause new concerns related to the currency composition of the available resources in respect of the potential liquidity problem.

52. In 1970, when the target for voluntary contributions to the General Fund was still \$2 million and the share of voluntary contributions allocated for the provision of technical assistance was \$1.5 million, the non-convertible currencies held by the Agency did not constitute a problem. In earlier years many recipient countries were still at the early stages of introducing nuclear techniques and could use basic equipment not requiring tropicalization. For the purchase of this type of equipment these particular currencies could readily be used. During the intervening years the level of the target and the quantities of the non-convertible currencies have steadily risen. At the same time the difficulties of matching more frequent requests for very specific and more advanced equipment on the one hand, with the assortment readily available for purchase with non-convertible currencies on the other, have increased considerably. In a programme calling for the utilization of all available resources the result has been a rapidly growing balance of non-convertible currencies that cannot be put to immediate use. This situation has serious implications for the future ability of the Agency to deliver the full approved regular programme. The Secretariat is making every effort to cope with the problem. If the present trends in the currency composition of available resources continue, special measures will become necessary in future years which may have a restrictive effect on annual programming.

53. In the report submitted to the Technical Assistance Committee in 1977 on the implementation of the Agency's regular programme of technical assistance it could be seen that 60% of the unobligated balance as at 30 September 1977 was in respect of expert

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[3] GC(XXII)/INF/177.

services. This situation may worsen if not enough qualified expert candidates are made available to the Agency. For example, with the continuing expansion in the nuclear power field in the developed and in the developing countries, the shortage of experts in nuclear safety and a number of critical areas relating to the planning of manpower development programmes and the construction of nuclear power plants is expected to become acute. In this connection it should be pointed out that the reactor exporting countries have a special responsibility towards the importing countries in making specialists available for the provision of the advice needed at various stages of nuclear power projects.

54. Besides the welcome increase in technical assistance resources there is ample scope for restructuring the Agency's regular programme. The substitution of many small and often single-component projects by a number of well-prepared multi-year projects should not only yield economies of scale but also make a more lasting impact in the recipient countries provided such projects have been integrated into the countries' development plans. The introduction of long-term programming of the assistance available from the Agency will not eliminate the need to assist small projects but it can be expected to make the regular programme more coherent. Another possible advantage of encouraging the developing countries to submit requests for longer term assistance is that such projects would also give the planned-economy countries a better opportunity of determining how their manufacturing capacity could best respond to the requirements contained in the Agency's technical co-operation programmes.

## NUCLEAR POWER AND REACTORS

### Nuclear and electric forecasts and economics

55. At the end of 1977, the world's installed nuclear plant power capacity was about 95 000 MW, or nearly 5.3% of the world's total electrical capacity. In the course of the year, more than 10 000 MW of new nuclear plant capacity came into operation. Twelve new nuclear power stations with a total capacity of 13 500 MW were ordered through firm contracts or letters of intent.

56. The estimated capital costs, both of nuclear and of conventional stations, continued to increase during the year primarily because of environmental and safety considerations. Natural uranium prices showed some degree of stability. However, there are now substantial uncertainties about the costs of reprocessing and recycling nuclear fuel, and even about the future availability of reprocessing facilities. Because of these uncertainties, the estimates for nuclear power growth to the end of the century are fairly wide (see Table 1).

Table 1

Estimates of installed total electric and nuclear capacity  
(in thousands of MW)

	1976	1977	1980	1985	1990	2000
Total electric	1700	1800	2200	2800-3000	3600-3900	5900-6600
Total nuclear	85	95	170	300-400	500-700	1300-2000
Percentage share of nuclear (%)	5	5.3	8	11-13	14-18	22-30

57. At the International Conference on Nuclear Power and its Fuel Cycle, held in May 1977 in Salzburg, Austria there emerged general agreement that nuclear power is the only source of energy which is at present technically and commercially able to bridge the energy gap that will occur as the result of the progressive exhaustion of fossil fuel resources.

58. It was noted at the Salzburg Conference that, although proven uranium resources are sufficiently large to guarantee the fuel supply of nuclear power plants that are now operating, under construction or planned, over the longer term it would probably be necessary to develop nuclear plants and supporting fuel cycles that permitted greater utilization of the energy content of fissile materials. The conclusions of the conference were reaffirmed by the tenth session of the World Energy Conference held in September 1977 in Istanbul, Turkey.

59. The Agency continued its economic and technical studies of nuclear power with a view to providing its Member States with up-to-date reports. Assistance in planning and implementing nuclear power programmes was provided to countries requesting support. Work has continued in the development of a computerized energy data bank that will contain economic data not only on nuclear energy but also on other forms of energy.

### Nuclear raw materials

60. Late in 1976 the Agency and NEA jointly established a Steering Group on Uranium Resources. This group gives guidance to the Joint NEA/IAEA Working Party on Uranium Resources in the preparation of the report "Uranium Resources, Production and Demand", and secondly supervises the International Uranium Resources Evaluation Project (IUREP), which will endeavour to assess the world's potential uranium resources. The joint

NEA/IAEA Group of Experts on Research and Development in Uranium Exploration Techniques met on two occasions in 1977. The Group sponsored three specialized workshops and it approved four projects with a total budget of \$4 000 000 over a period of three years.

61. During the year the following meetings were held:

- (a) A regional advisory group meeting on uranium deposits of Africa in November in Lusaka;
- (b) A technical committee meeting on natural fission reactors in December in Paris. This meeting was held in collaboration with the French Atomic Energy Commission;
- (c) The international working group meeting on natural fission reactors for the co-ordination of follow-up activities of the Agency's symposium on the Oklo phenomenon; and
- (d) A co-ordination meeting on bacterial leaching of uranium ores and on uranium deposits in sandstone host rocks.

62. The Agency is providing technical assistance in uranium exploration, development of ore deposits and ore processing to 27 countries. These undertakings include UNDP large-scale projects in Chile, Greece, Pakistan, Peru and Turkey. During 1977 the projects in Greece and Turkey were concluded and the one in Peru started.

#### Fuel element technology

63. This sub-programme is concerned with the exchange of information on the fabrication and performance of light-water-reactor fuels, on quality assurance and quality control and on other aspects of the reliability of reactor fuels. The main activity in this field was carried out within the framework of the International Working Group on Nuclear Fuel Performance and Technology, which was established in 1976.

64. The UNDP project in Romania to develop a nuclear power reactor programme was given significant technical support. The initial phase 1 of the project was completed in 1977, and phase 2 of the project is under way.

65. Technical assistance was provided to Brazil, Indonesia, Mexico and other Member States in their fuel development programmes.

#### Regional nuclear fuel cycle centre project

66. The study of the concept of regional nuclear fuel cycle centres, started by the Agency in 1975, was completed in early 1977 and a two-volume report was issued in May, prior to the Salzburg Conference on Nuclear Power and its Fuel Cycle. Considerable interest was expressed at the Conference in this study, and a number of participants were of the opinion that it offered many advantages, particularly with respect to non-proliferation objectives. Mathematical models and computer codes developed by the Agency for this study may also be utilized for the evaluation of alternative fuel cycle strategies. The institutional-legal arrangements examined in this study are expected also to be of value in any further development of the concept by interested Member States.

#### Spent fuel storage, reprocessing and recycling

67. The major activities in these areas have been carried out within the framework of the Agency's studies of regional nuclear fuel cycle centres and plutonium management under the Agency's auspices. Results of the studies were published. A consultants' meeting was held concerning the status of the technology for the storage of spent fuel.

### Nuclear technology and reliability

68. A report on operating experience with nuclear power plants in 1976 supplemented by an annual analytical summary report has been published. The publication "Power Reactors in Member States" has been updated and issued in 1977.

69. The international working group on reliability of reactor pressure components and the international working group on nuclear power plant control and instrumentation organized several specialists' meetings in 1977. A symposium on the application of reliability technology to nuclear power plants was held in Vienna in October 1977. A technical committee meeting on heat utilization from nuclear reactors for desalting of sea water was convened in Vienna in June 1977. At an advisory group meeting in Athens the status of small and medium reactors was analysed, and technical and economic information reviewed and updated.

### Advanced nuclear power technology and reactor physics

70. Two experimental fast breeder reactors were commissioned in 1977: JOYO in Japan and KNK-II in the Federal Republic of Germany. Operating experience continued to be accumulated on the demonstration plants BN-350 in the Soviet Union, Phénix in France and PFR in the United Kingdom and construction is in progress on the world's first commercial-size fast breeder reactor, Super-Phénix, in France.

71. Countries participating in the International Working Group on Fast Reactors, which held its tenth annual meeting in 1977, continued to give high priority to developing and deploying fast breeder reactors, with the exception of the United States of America, which has delayed its breeder programme.

72. A preliminary report presented at the Salzburg Conference by a group of consultants emphasized the important role thermal-breeder reactors could play, together with fast breeder reactors, in limiting world uranium ore requirements in the next century. There is continuing widespread interest in the development of high-temperature reactors for electrical and industrial applications.

73. In the field of magnetohydrodynamics the IAEA/UNESCO International Liaison Group for MHD Electrical Power Generation held its thirteenth annual meeting, organized the eighth specialists' meeting on closed-cycle MHD and issued the 1976 status report on MHD electrical power generation.

### Nuclear explosions for peaceful purposes (PNE)

74. The Ad Hoc Advisory Group on Nuclear Explosions for Peaceful Purposes submitted its report on nuclear explosions for peaceful purposes to the Board in September 1977. The report was distributed for information and comment to all Member States of the Agency and transmitted to the Secretary-General of the United Nations for the information of its Member States.

75. The Board decided that the subject matter of the report should be kept under review and that consideration of the matter should be continued when appropriate, the services of the Ad Hoc Advisory Group continuing to be available as required. It requested the Director General to keep it and Member States informed of any development concerning the subject matter of the Ad Hoc Advisory Group's report.

76. The Agency participated as an observer at the third meeting of the Qattara Steering Committee, where the progress of the feasibility study of Egypt's Qattara power project, a potential PNE application, was reviewed.

## NUCLEAR SAFETY AND ENVIRONMENTAL PROTECTION

### General

77. By the end of 1977, the 206 commercial nuclear power stations in operation in the Agency's Member States had accumulated 1500 reactor-years of operating experience and no fatalities or serious injuries were reported which were directly attributable to the nuclear side of the industry - from mining and milling of uranium through to the storage or disposal of radioactive wastes.

78. The Agency's arrangements for emergency assistance for radiation accidents were revised and formally co-ordinated with the Office of the United Nations Disaster Relief Co-ordinator in Geneva.

### Nuclear safety

79. The Agency's regular safety inspections of research reactors have continued, and in 1977 missions were sent to Brazil, Chile, Colombia, Japan, Mexico, the Philippines, the Republic of Korea, Uruguay and Venezuela. In addition, advice was given in Ecuador concerning the safe siting of a nuclear research centre.

80. Nuclear power plant siting and safety missions were sent to an increasing number of Member States. Siting missions visited Argentina and Malaysia; safety advisory reports were reviewed with the appropriate national authorities in Brazil, Mexico, the Philippines and the Republic of Korea; and safety advice was given to Chile, Greece, the Philippines, Portugal and Turkey.

81. The Agency convened an advisory group to recommend the scope and direction of the Agency's programme in the field of thermal reactor safety research and development. In co-operation with NEA a symposium on the safety of nuclear ships was held by the Agency in Hamburg, Federal Republic of Germany, at which the urgent need for internationally acceptable documents on the safety of nuclear merchant ships was noted.

82. In the nuclear safety standards programme, Codes of Practice on Governmental Organization, Siting, Design, Operation and Quality Assurance were completed for recommendation to Member States. In addition, 25 Safety Guides are being prepared and have reached various stages of the reviewing process.

### Radiological safety

83. A symposium on the handling of radiation accidents, organized jointly by the Agency and NEA, was held in Vienna in February. The principal theme was emergency procedures for handling nuclear power plant accidents.

84. An advisory group was convened in March to consider the Agency's future work on the safe transport of radioactive materials. On the basis of the recommendations of this group, an expanded programme has been drawn up with the aim of assisting Member States to apply the transport regulations effectively.

85. A symposium on the monitoring of radioactive airborne and liquid releases from nuclear facilities, held in Portoroz, Yugoslavia, in September, reviewed the objectives of effluent monitoring programmes and the techniques and instrumentation now available. It appears that, in general, adequate monitoring techniques have been developed to give assurance to the operators of facilities, to regulatory and health authorities, and to the general public, that the facility is operating within the authorized limits and that the population and the environment are being adequately protected.

86. In November, the Agency held a regional seminar for countries in Latin America on radiological protection in nuclear programmes in Caracas, Venezuela. The participants

discussed radiological and environmental protection problems and possible regional co-operation on research and other projects.

87. Two radiological safety publications, the Basic Safety Standards for Radiation Protection and the Code of Practice on Basic Requirements for Personnel Monitoring, were revised, taking account of the new recommendations of the International Commission on Radiological Protection (1977).

88. Manuals of guidance were prepared on:

- (a) The monitoring of radioactive airborne and liquid releases from nuclear facilities;
- (b) Radiological safety aspects of the operation of electron linear accelerators;
- (c) The role of chelating agents in the treatment of incorporated transuranic elements;
- (d) First aid treatment of radiation injuries and sodium burns;
- (e) The decontamination of surfaces and working areas; and
- (f) Methods for the assessment of collective dose.

#### Waste management

89. The Agency held a regional seminar in Buenos Aires, Argentina, in August/September, on the application of environmental impact analysis to the nuclear power industry. The Agency collaborated with NEA in a technical seminar held in Paris, in December, on the treatment, conditioning and storage of solid alpha-bearing waste and cladding hulls.

90. On the advice of a consultants' group, the Agency began the preparation of guidelines which are to be published first as technical documents, for the disposal of radioactive wastes into geological formations. A report on site selection factors for repositories of solid high-level and alpha-bearing wastes in geological formations was published in the Technical Reports Series. Another report, on techniques for the solidification of high-level wastes, was also published.

91. A code and guide on the waste management aspects of decommissioning land-based nuclear reactors has been drafted. The drafting of codes and guides on the management of wastes from uranium refining and enrichment has also been started.

92. The final co-ordination meeting for the co-ordinated research programme on the cycling of tritium in different types of ecosystems resulted in the drafting of a booklet on the results and methodology. This will be published and presented at an international symposium on the behaviour of tritium in the environment, in October 1978.

93. In co-operation with UNEP, the Agency held an advisory group meeting to review available methods for studying the effects of releases of radioactivity in aquatic environments and to compile detailed procedures for performing experiments that will produce reliable data for use in assessing the impact of nuclear activities on the aquatic ecosystems on which man depends.

94. Pursuant to the Agency's responsibilities under the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention), the Agency has continued its programme of preparing revised definitions and recommendations.

#### Joint IAEA/IIASA research project

95. Research was carried out in the areas of risk estimation and risk evaluation. Studies in the area of risk estimation concentrated on three approaches:

- (a) Comparisons of risks related to various energy supply technologies;
- (b) Estimation of risks not related to energy production; and
- (c) Comparisons of expenditures to reduce risks.

96. In the area of risk evaluation, a psychometric model was used which allows the objective measurement of public attitudes towards technologies. An application of this model using a large heterogeneous sample showed that four major factors underlie the public attitude towards nuclear power: three risk factors (physical, psychological and social-political) and a benefit factor. The relative importance of these factors was found to be quite different for groups in favour of and opposed to nuclear power. Investigations have been made of the use of risk estimation data and attitude data in decision-making. Five Member States participated in this project in 1977 by seconding scientists.

## FOOD AND AGRICULTURE

### General

97. Under the joint FAO/Agency programme of food and agriculture, nuclear techniques are applied to help solve problems of food production and preservation and of protecting the agricultural and fisheries environment from the side effects of fertilizers, pesticides and pollutants. The objectives of the programme are achieved by the provision of training and other kinds of technical assistance; by co-ordination and support of research; and by the dissemination of information. During 1977 the Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture had technical responsibility for over 50 technical assistance projects in 36 developing Member States. More than 200 laboratories and other institutions in Member States participated in some 24 co-ordinated research programmes.

### Crop production

98. The co-ordinated research programme to develop efficient methods of applying fertilizers to grain legumes (soya bean, common bean, broad bean and ground nut) was completed. These investigations have shown that split applications of nitrogen fertilizer in combination with appropriate irrigation practices lead to efficient use of applied nitrogen. An important achievement was the clear indication that nitrogen-15 can be used to obtain an integrated measure of the amount of total nitrogen fixed by legumes throughout the growing season.

99. The co-ordinated research programme, supported by the Federal Republic of Germany, on conserving nitrogen as a plant nutrient in the soil and controlling losses caused by leaching of nitrogen below the root zone was continued. A three-year field experiment aimed at examining the fate of fertilizer nitrogen in multiple cropping systems with the help of nitrogen-15 has been started in ten Member States.

100. The co-ordinated research programme on micronutrient deficiencies in flooded rice soils was continued. The studies in 1977 have contributed significantly towards the development of rapid soil analytical methods, which are being used for predicting the zinc status of soils in nine Member States. Using zinc-65, valuable information is being obtained on the most efficient form and method of application of zinc fertilizer for flooded rice grown on zinc-deficient soils.

101. The co-ordinated research programme on soil water regimes will be completed during 1978. Scientists from 12 Member States made comprehensive studies on hydraulic conductivity as a function of soil moisture content and estimation of drainage component.

102. Two new co-ordinated research programmes were approved in 1977. One deals with the biological fixation of atmospheric nitrogen by crops and a study of management practices that could decrease the need for applying nitrogen fertilizer. The other programme aims at increasing soil-water storage under dry farming conditions in semi-arid regions through increasing water infiltration, reducing evaporation and application of organic matter. Isotope and radiation techniques play an essential role in both programmes.

### Crop improvement

103. An FAO/IAEA regional seminar for Asia and the Pacific on improvement of rice production through research using nuclear techniques was held in Jakarta, Indonesia. Representatives from ten Member States discussed the contributions nuclear techniques have made in rice research, particularly with regard to genetic improvement, fertilizer applications and insect pest control.

104. An IAEA/UNDP technical assistance project in Pakistan resulted in the release of a mutant rice variety "Kashmir Basmati" for cultivation in the northern provinces of Pakistan. Another mutant rice variety, "Nucleoryza", resulting from a co-operative

project between the Agency Laboratory and Hungarian plant breeders, was grown successfully in 1977 on a large commercial scale at collective farms in Hungary. Reports received during the year indicate that 27 new plant cultivars resulting from mutation breeding were released in different parts of the world. Thirteen of the new cultivars were cereals, three were other crop plants and eleven were ornamentals.

105. Genetically determined resistance of crop plants to diseases caused by pathogenic organisms was the topic of an international symposium held in Vienna in 1977. Papers at the symposium reviewed the results of a five-year co-ordinated research programme which was supported by SIDA. A four-week training course on plant breeding for disease resistance including the utilization of induced mutation techniques was held in New Delhi.

106. An advisory group meeting was convened in Dakar, Senegal, to study the possibilities of developing better resistance of crop plants to insect pests by utilizing mutagen-induced genetic variants. The experts concluded that in some cases induced mutations could be utilized now.

#### Insect control

107. The Agency and Nigeria signed a large-scale project agreement for suppressing the tsetse fly by the sterile-insect technique (SIT) in June 1977. Several Member States have contributed funds and the initial phases of the project are being implemented. Through contracts and a co-ordinated research programme, the Agency is providing technical support to Member States interested in tsetse fly control by the SIT.

108. The co-ordinated research programme on the use of the SIT to control fruit tree pests ended this year. A successful demonstration of the technical feasibility of using the SIT for control of the codling moth was conducted in Canada.

109. The threat of invasion in Mexico of the Mediterranean fruit fly has resulted in a major SIT programme by Mexico for which this country has asked assistance and guidance from the Agency. In this connection, the Seibersdorf Laboratory is developing methods for the large-scale production of sterile Mediterranean fruit flies and technical assistance is being provided in the form of experts, equipment and shipments of sterile flies. A one-year agreement has been concluded with the Mexican Government and USDA-APHIS (the Animal and Plant Health Inspection Service of the United States Department of Agriculture) for the large-scale use of the sterile-insect technique in the control and/or eradication of the medfly in the northern part of Central America; under the agreement, the Agency is supplying (on a cost-reimbursable basis) 35 million irradiated Mediterranean fruit fly pupae a week.

#### Animal production and health

110. The Agency is continuing work on the use of isotopes to study the water requirements of livestock in arid and semi-arid environments. These investigations have been successful in identifying species and breeds of animals that are able to maintain reproduction and growth under conditions of water restriction. A programme to use nuclear techniques in the study of reproductive problems has led to the identification of factors responsible for poor reproductive performance of farm animals in the developing countries. The co-ordinated research programme on the use of isotope techniques to diagnose moderate mineral imbalances in farm animals is continuing. Simple methods for diagnosing selenium and copper deficiency at an early stage have been developed through this programme.

111. New co-ordinated research programmes are being started on the use of isotopes in the study of mechanisms to control the spread of ticks and tick-borne diseases, and on the use of isotopic techniques to study means of improving domestic buffalo production.

#### Protection of the environment

112. Co-ordinated research programmes involving the use of isotopes as tracers in environmental studies on the following subjects were continued:

- (a) Fertilizer nitrogen residues in the soil;
- (b) Pesticide residues in oil-seeds and oil-seed products; and
- (c) The effects of agro-chemical residues on inland fisheries.

113. Two new co-ordinated programmes were started respectively to study: (a) the interactions between soil organisms and agrochemical residues and the capacity of soil to degrade undesirable chemical residues (e.g. those of pesticides); and (b) the interactions between sensitive crops and sulphur-containing pollutants in the atmosphere.

#### Food preservation

114. The positive recommendations made by the joint FAO/IAEA/WHO expert committee in 1976 concerning the wholesomeness of a number of irradiated foods, and pertinent technological data, have been submitted for acceptance to the Codex Alimentarius Commission of the Joint FAO/WHO Food Standards Programme.

115. Negotiations on the establishment in Wageningen, Netherlands, of an International Facility for Food Irradiation Technology (IFFIT) were conducted with a view to reaching a trilateral agreement between FAO, the Government of the Netherlands and the IAEA. IFFIT will be used as a centre for training and studies on the technological and economic feasibility of food irradiation.

116. A meeting on radiation preservation of fish and fishery products was held in February in Bombay, India. An advisory group meeting on food irradiation and an international symposium on food irradiation were held in Sofia and in Wageningen, Netherlands, respectively.

## LIFE SCIENCES

### Medical applications

117. Under a co-ordinated research programme, a survey of maintenance of nuclear medicine instruments is in progress in eight countries in South East Asia. Initial steps towards establishing similar investigations in the Near East, Africa, and Latin America have been taken.

118. Nuclear medicine instrument systems are being reviewed with regard to technical requirements for their effective use in developing countries. The examination of well-scintillation counters has been completed; a publication with recommendations on such devices has been issued, and prototypes incorporating some of these recommendations have been built and are being tested.

119. Recent advances in radioimmunoassay and related procedures were reviewed at an Agency symposium in Berlin (West), and an advisory group, which met in Vienna in December, made recommendations with regard to facilities required for in vitro radioassays in developing countries. Special stress was laid on the importance of and methods for quality control.

120. In collaboration with the International Committee for Standardization in Haematology, a report was prepared on the use of radioisotopes in the clinical testing of iron utilization by the body, and a study was started of methods for measuring vitamin B<sub>12</sub> absorption.

121. A group of consultants made recommendations on techniques for radioisotope studies of kidney function.

122. Research co-ordination meetings were jointly held with WHO on trace elements in cardiovascular diseases and trace elements in human nutrition (particularly relating to the composition of human milk).

### Dosimetry

123. At the end of 1977, the IAEA/WHO Secondary Standards Dosimetry Laboratories (SSDL) network comprised 29 members and a number of additional applications for membership have been received.

124. The joint IAEA/WHO postal cobalt-60 teletherapy dosimetry service was serving 160 institutions during 1977, as compared to 140 in the previous year.

125. A pilot postal dose-intercomparison study (thermoluminescence dosimetry) for orthovoltage X-ray therapy has been successfully carried out.

126. By the end of 1977, a total of 166 californium-252 needles had been distributed in 23 Member States.

127. A preliminary dosimetry intercomparison study in anticipation of a new programme was conducted between nine laboratories having large cobalt-60 gamma-irradiators for industrial radiation processing.

128. A symposium on national and international standardization of radiation dosimetry was held in Atlanta, United States of America, with 136 participants from 26 countries.

### Radiation biology

129. The programme on the use of radiation for sterilizing medical supplies in Europe was terminated and the findings are being analysed. A regional research co-ordination

programme has been started on radiation sterilization practices in the countries of Asia, the Far East and the Pacific region with emphasis on the specific needs for their local medical supplies and on conditions.

130. The Agency has continued to promote research on immunological control of human parasitic diseases by radiation-attenuated parasites, with particular emphasis on malaria, in collaboration with WHO.

131. The co-ordinated research programme on the modification of cellular radiosensitivity was continued. The scope of this programme was extended to include the application of heavy particles for radiation therapy.

132. A technical committee meeting was held to review and complete available data on the radiosensitivity of pathogenic micro-organisms in sewage in order to provide a standard reference for the application of radiation in sewage treatment.

133. The comparative assessment of the biological hazards of major chemical pollutants with those of low doses of radiation revealed that the majority of chemical pollutants caused biological hazards of a type that permits comparison of these chemical pollutants with radiation in equivalent units.

134. The Agency is continuing its support of co-ordinated research on the suitability of chromosomes as a test material to ascertain possible biological hazards to man from exposure to low doses of radiation.

#### Health-related environmental research

135. The ongoing activity on the use of neutron activation for the analysis of trace amounts of inorganic pollutants in human hair as an indicator of man's exposure to these pollutants was supplemented by the use of accelerator-based methods: charged-particle, fast neutron and photon activation analysis, proton induced and heavy ion induced X-ray emission analysis.

136. The first estimates of the health impacts of nuclear power as compared to those from conventional sources of energy, in terms of hazardous events per 1 MWh of energy, disclosed a wide gap in favour of nuclear power.

## PHYSICAL SCIENCES

### Physics

137. The nuclear physics programme takes the form chiefly of technical assistance projects and research contracts. A co-ordinated research programme on the application of Mössbauer spectroscopy in mineralogy, soil sciences and ceramics was started. An advisory group met in San José, Costa Rica, to analyse the status and potential of contemporary nuclear techniques used in applied research. The co-ordinated research programme on elemental analysis using proton-induced X-ray fluorescence was terminated following a meeting in Athens.

138. The programme on research reactor utilization included the preparation of publications on reactor scattering techniques in applied research. An international symposium on neutron inelastic scattering was held in Vienna. Research contracts were started on safety-oriented experiments that can be performed with research reactors. A compilation of research reactor data, concentrating on fuel cycle and utilization, was started.

139. The Agency continued to assist international collaboration in fusion research. At a meeting on fusion reactor concepts held in Madison, United States of America, potential designs and engineering details of future fusion reactors were presented. The observed losses of energy and particles in magnetic confinement systems were discussed at an advisory group meeting on cross-field conduction and transport held in Kiev, Ukrainian Soviet Socialist Republic. A co-ordinated research programme on surface effects of importance to fusion reactors continues to draw on facilities and scientists in developing countries who wish to contribute to the international fusion programme.

140. The International Fusion Research Council updated its Status of Fusion Report at a meeting held at the International Centre for Theoretical Physics, Trieste. The report assesses the potentials of fusion reactors, considers environmental effects and suggests goals which might be reached.

### Industrial applications and chemistry

141. A symposium held in Vienna in March 1977 reviewed the current status of nuclear techniques in exploration, extraction and processing of mineral resources. Five projects on the use of nuclear techniques for mineral prospecting and trace element analysis were completed. Under co-ordinated programmes, institutes in seven Member States are carrying out research on X-ray and neutron techniques for industrial process control and on electron-capture detectors in gas chromatography.

142. A number of contracts have been awarded to various Member States to carry out research on radiopharmaceuticals and on radiation processing of industrial products.

### Isotope hydrology

143. An advisory group met in Vienna to review the potential use of nuclear techniques to investigate water balance, mixing and sedimentation in lakes. An inter-secretariat (IAEA/WMO/UNEP) group met to integrate the aims of the Isotopes in Precipitation Survey (IAEA/WMO) and the Global Environmental Monitoring System (GEMS) of precipitation (UNEP/WMO).

144. Subcontractual services in isotope hydrology were provided for UNDP projects in Ecuador, Guatemala, India and the Libyan Arab Jamahiriya. Advisory services including laboratory analyses were provided to Austria, Bulgaria, Greece, Mexico and Pakistan and assistance is being provided for the establishment of environmental isotope analytical facilities in Greece, Jordan, Mexico and Turkey.

## Nuclear data

145. At a meeting of representatives of nuclear-reaction data centres, it was agreed to adopt a universal computer-based system for the storage, retrieval and exchange of numerical nuclear-reaction data. The co-ordinating efforts towards the establishment of a world-wide computer library of nuclear data for reactor neutron dosimetry were continued.

146. Targets and sample material worth \$30 000 were distributed to nuclear physics laboratories in developing countries to perform nuclear data measurements. A co-ordinated research programme on the intercomparison of evaluations of actinide neutron-cross-section data was started in the course of the year. A co-ordinated research programme for the measurement and evaluation of transactinium isotope nuclear decay data was also started in 1977.

147. Specific computer-based systems for the exchange of bibliographic and numerical nuclear structure and decay data were adopted at a meeting of representatives of data centres, who also agreed to a continuous and complete evaluation of nuclear structure and decay data for all isotopes on a four-year cycle.

148. Publication of a quarterly International Bulletin on Atomic and Molecular Data for Fusion was started in 1977. At a meeting of representatives of national atomic data centres and groups, it was agreed to co-operate in the systematic world-wide compilation, evaluation and dissemination of atomic and molecular data required for fusion.

## THE LABORATORIES

### Seibersdorf Laboratory

#### Chemistry

149. During the year 408 institutes in 52 Member States participated in the Analytical Quality Control Programme and received a total of 386 standard or reference materials as well as 353 intercomparison samples of biological, environmental or geological materials. Several thousand analytical data were evaluated. The results were returned to the participating institutes and were also reported in the literature and at scientific meetings.

150. Analytical services, mainly to uranium prospecting projects in Member States, involved 1200 analyses of 900 samples. Additionally, 2500 analyses of 1100 samples were carried out in support of a training course on geochemical prospecting for uranium.

#### Safeguards Analytical Laboratory (SAL)

151. Plutonium fuel and spent fuel samples are now being received for analysis in addition to uranium-containing samples. 350 uranium and 20 plutonium samples have been received and analysed. The samples of spent fuels are being analysed by isotopic dilution mass spectrometry. Analysis of spent fuel requires the preparation and calibration of tracers containing a known amount of  $^{233}\text{U}$  and  $^{242}\text{Pu}$  isotopes. A programme of development has been started for the analysis of minute spent fuel samples containing only nanogram quantities of plutonium.

152. Under the Agency's analytical quality control services, SAL has characterized and distributed  $\text{UO}_2$  product type samples to 36 laboratories in Member States.

#### Agriculture, including entomology

153. Under the co-ordinated research contracts programme the Laboratory:

- (a) Analysed a total of 8000 plant and soil samples for nitrogen-15 content, 7000 by mass spectrometry, the remainder by emission spectrometry;
- (b) Developed methods to screen seed protein mutants in various cereal species. The Laboratory is now able to analyse 40 000 samples a year for seed protein characteristics using at least three different methods;
- (c) Irradiated batches of seed material for mutation breeding, mainly for breeders in developing countries, and provided training in mutation breeding techniques;
- (d) Improved the methods of mass rearing of the Mediterranean fruit fly, and now supplies expertise, equipment and flies for a large Mexico/USA programme;
- (e) Continued its support of the USA/Tanzania and the Agency/Nigeria tsetse fly projects on reproductive biology and in vivo and in vitro rearing research.

#### Metrology

154. Within the intercomparison service of calibrated radionuclide solutions, 30 samples of 16 different radionuclides calibrated by seven national standards laboratories were received and registered. Eight calibrations were performed by the Laboratory and incorporated in the tables.

155. In connection with an intercomparison on behalf of the International Committee for Radionuclide Metrology, the emission rates of 10 gamma-rays from  $^{152}\text{Eu}$  were measured by Ge(Li) spectrometry.

International Laboratory of Marine Radioactivity

156. The main areas of research during the year were:

- (a) Assessment of the behaviour of natural alpha-emitting radionuclides and transuranic elements in certain marine plant and animal food chains;
- (b) Studies on the effects of pollutants such as mercury and other metals on marine plants and animals;
- (c) Intercalibration exercises in radionuclide measurements organized during 1977 have specifically been oriented to those on marine sediment samples. After testing the homogeneity of the samples they were distributed to about 60 national institutions in about 25 Member States. The results of these measurements are now being reported;
- (d) Measurements of transuranic elements in the Mediterranean were extended to the eastern basin. Profile samples down to approximately 2000 m were collected at several stations and the analysis is now in progress;
- (e) Trace metal measurements on sea-water samples were extended to include off-shore areas of the Mediterranean. The results of these measurements show that the concentrations of Cu, Zn, Cd and Hg are, in general, very low from the surface to the bottom in these off-shore areas;
- (f) Recent studies have shown the important role of faecal pellets from surface plankton in removing transuranic elements from the water and putting them into the sediments. The Laboratory is investigating how to determine the level of the radionuclides once they have been incorporated into sediments and if these transuranics are then available for uptake by benthic species;
- (g) Studies on the distribution of radioactive and stable nuclides in populations of copepods, mussels and fish eggs were carried out;
- (h) More precise computational methods for determining the dose rate to fish eggs in environments contaminated with radioactivity have been developed; and
- (i) A radioecological classification of dose-rate zones of chronic irradiation of aquatic organisms and ecosystems by ionizing radiations was proposed.

157. Research on non-nuclear pollutants, carried out under several UNEP contracts comprised:

- (a) Studies on the effects of chlorinated hydrocarbons on marine organisms. The role of polychaete worms in concentrating polychlorinated biphenyls (DP-5) from the sea sediment was estimated. DP-5 uptake at sea and under laboratory conditions by mussels was compared. The transfer of DP-5 through marine food chains, including aquatic and sediment environment, mussels, worms and shrimps was investigated and a field study of the role of sinking particulate products in the vertical flux of chlorinated hydrocarbons in the open ocean was carried out;
- (b) As a second step in the intercalibration of trace element measurements, sea plant and copepod homogenates were distributed to about 100 laboratories and

the analytical results were assembled. An in-depth survey of these results is in progress. While the comparability of the results has been considerably improved, the analysis of Pb still poses a problem. The preparation of fish-flesh homogenate was completed and it was made ready for distribution. Considerable difficulty was encountered in obtaining reasonable homogeneity of this sample. A new procedure for analysis of Hg in marine environmental samples by atomic absorption spectrophotometry was developed and applied to sea-water, suspended matter and biological samples collected from the Mediterranean;

- (c) Samples of sediment, sea-water, air and biota were collected during five oceanographic cruises in the Mediterranean Sea. These samples are being analysed for chlorinated hydrocarbons;
- (d) Co-ordination of the intercalibration exercise within the framework of the Mediterranean Pollution Monitoring and Research Programme (UNEP/FAO/IOC) will continue throughout 1978;
- (e) Plankton and nekton have been sampled throughout the open waters of the Mediterranean and are being analysed for several important heavy metals, metalloids and chlorinated hydrocarbons; and
- (f) Nuclear techniques are being used to study the behaviour of arsenic and vanadium in important marine plant and animal food chains.

## INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS

158. The main fields of research and training-for-research at the International Centre for Theoretical Physics during 1977 were:

- (a) Atomic, molecular and laser physics;
- (b) Plasma physics;
- (c) Elementary particles and fundamental theory;
- (d) Solid-state physics;
- (e) Science teaching;
- (f) Solar energy;
- (g) Physics of the earth; and
- (h) Applicable mathematics.

159. The year began with a winter college on atomic and molecular physics, with the participation of nearly 100 scientists.

160. A college dedicated to theoretical and computational plasma physics, attended by more than 150 scientists, was one of the main highlights of the year. During the last week of the college, the Third International (Kiev) Conference on Plasma Theory took place at the Centre which, immediately afterwards, also hosted the Agency's International Fusion Research Council.

161. Research in elementary particles and fundamental theory was continued throughout the year and was enhanced by three topical meetings.

162. In solid state physics, the Centre organized a three-month workshop, including a symposium on one-dimensional conductors.

163. The science teaching programme featured a summer school, held in collaboration with the University of Grenoble (France), the Ecole Normale Supérieure (Paris), the University of Louvain-la-Neuve (Belgium) and the University of Montreal (Quebec, Canada). The course was held entirely in the French language, mainly for the benefit of university physics teachers from French-speaking African countries, with the financial support of the French Ministries of Foreign Affairs and of Co-operation.

164. A new endeavour of the Centre was the course on solar energy conversion, held in collaboration with the International College of Applied Physics (Catania), which brought together 200 scientists and representatives of institutions and industries interested in this subject.

165. Also of interest to many was the autumn course on physics of the earth, including a one-week advisory meeting on earthquake prediction.

166. The year ended with a workshop on boundary value problems for ordinary differential equations, the applications of which are widespread.

167. The Centre also provided scientific guidance to the second course on physics and contemporary needs, held in Nathiagali, Pakistan, as a follow-up to the course in 1976 on the same subject.

168. Approximately 1300 scientists visited the Centre during 1977. Of these, 174 were from Africa (an increase of some 250% over the previous year). A large proportion of the total number of visitors came from developing Member States and again this year about 75% of the financial resources available for scientific activities was used to support the Centre's work for scientists from developing countries.

169. Financial and other assistance continued to be given by the Italian Government and local authorities in Trieste. Funds were also received from the Government of Sweden through SIDA as well as from UNDP, the International Union of Geophysics and Geodesy, the International Union of Pure and Applied Physics and the Province of Quebec (Canada), and indirect financial support was provided by the Organization of American States.

## SAFEGUARDS

### General

170. In 1977, The Director General submitted a Safeguards Implementation Report, covering the year 1976, to the Board of Governors. The principal conclusion of the report was that in none of the 40 States in which the Agency carried out inspections during 1976 was there any diversion of a significant quantity of safeguarded nuclear material, and the Secretariat was also confident that there was no diversion at all of such material in these States. The Director General pointed out that this conclusion was based partly on quantitative analyses and partly also upon elements of judgement, and that it was a continuing aim of the safeguards programme to increase the Agency's ability to base its safeguards conclusion on quantitative verification activities. The second Safeguards Implementation Report analyses the Agency's safeguards operations during the year 1977.

171. It similarly concludes that in 1977, as in 1976, the Agency's safeguards operation did not detect any diversion of a significant quantity of nuclear material. The Agency is able to confirm, taking into account all circumstance, including qualitative observations, that in all 40 States where safeguards agreements were in full implementation all safeguarded nuclear material remained in the declared peaceful nuclear activity or was otherwise adequately accounted for.

172. Three major developments influenced Agency safeguards in 1977: the broadening of their scope, as a result, for instance, of the conclusion of new agreements and the replacement of some existing agreements; the further review and classification of safeguards criteria; and actions initiated as a result of the evaluation of safeguards effectiveness which was carried out for 1976 and presented in the Special Safeguards Implementation Report.

173. Four additional States with a large number of facilities came under NPT safeguards. The total number of facilities under Agency safeguards increased by approximately 50%. Many of the new facilities involve sophisticated nuclear activities and materials of high strategic value, and they require significantly more intensive safeguards. Measured in man-days at facilities, the inspection effort was more than 60% greater in 1977 than in 1976. The amount of nuclear material under safeguards had increased significantly by the end of 1977: about 100% more plutonium, over 200% more highly enriched uranium and over 100% more low enriched uranium and source material.

174. In general, the proportion of safeguarded nuclear material covered by NPT agreements has increased considerably. In the case of certain States with agreements based on document INFCIRC/66/Rev.2, it has also been possible to agree on safeguards procedures and measures not explicitly provided for in those agreements but similar to those provided for in document INFCIRC/153 (Corrected).

175. The changes are partly reflected in an increase in the amount of information contained in accountancy reports submitted by States to the Secretariat. The amount of information (not counting design information) to be handled, understood and utilized was five times larger in 1977 than in 1976, amounting to the reporting of more than 170 000 nuclear material movements and physical inventory details.

176. The Standing Advisory Group on Safeguards Implementation (SAGSI) held its fourth meeting in September 1977, during which it reviewed the 1976 SSIR and considered the quantification of the technical objectives of safeguards. The detailed discussion of the latter dealt chiefly with:

- (a) The amount of nuclear material required for the manufacture of a nuclear explosive device ("threshold amounts");
- (b) The amounts of nuclear material regarded as significant from the point of view of safeguards ("quantities of safeguards significance"); and

- (c) The time required to convert various nuclear materials into a metallic component directly usable in a nuclear explosive device ("conversion times").

SAGSI made a number of recommendations on each of these points.

177. Preliminary discussions continued during 1977 with the United Kingdom and the United States of America concerning the implementation of their offers to place civil nuclear facilities, except those having a direct national security importance under the Agency safeguards. The relevant safeguards agreements, it will be recalled, were approved by the Board of Governors in 1976. The Agency also started to negotiate with France an agreement similar to the agreement concluded with the United Kingdom.

#### Safeguards operations

178. At the end of 1977 the Agency had a total of 119 safeguards agreements in force with 74 States, and with 15 States it had concluded 15 safeguards agreements awaiting entry into force.

Table 2

NPT and NPT-type agreements in force

NPT	42
NPT and Tlatelolco Treaty	8
NPT and Additional Protocol I of Tlatelolco Treaty	1
	<hr/>
	51

Table 3

Non-NPT agreements in force<sup>a/</sup>

Project Agreements	23
Unilateral Agreements	14
Trilateral Agreements	31
	68

a/ Pursuant to the entry into force of safeguards agreements in connection with NPT the application of Agency safeguards has been suspended in the case of 28 of the above agreements: 14 project agreements, one unilateral submission and 13 trilateral agreements (in the last category of agreements the suspension applies to both parties in two cases and to one party only in 11 cases).

International coverage of Agency safeguards

179. A detailed analysis of the situation with regard to NPT is given in Table 8.

180. As of 31 December 1977, the Agency had been informed by the depositary Governments of the ratification or accession to NPT by 102 States [4], including three nuclear-weapon States.

181. Of the 99 non-nuclear-weapon States concerned, 66 had concluded the safeguards agreements with the Agency required by Article III.2 of NPT. Of these States 55 had safeguards agreements in force. The deadline set by Article III.4 of NPT for the entry into force of the safeguards agreements had elapsed for the non-nuclear-weapon States listed in Table 4.

[4] Viet Nam is reconsidering adherence to the commitments of the former Administration under international agreements.

Table 4

Non-nuclear-weapon States Party to NPT which by 31 December 1977 had not yet complied with Article III, 4 of the Treaty stipulating the deadline for the entry into force of the relevant safeguards agreement to be concluded with the Agency

Afghanistan <sup>a/</sup>	Libyan Arab Jamahiriya
Bahamas	Mali
Benin	Malta
Bolivia	Nigeria
Botswana	Panama
Burundi	Paraguay
Central African Empire	Peru
Chad	Rwanda
Costa Rica	Samoa
Democratic Kampuchea	San Marino
Gabon	Senegal
Gambia	Sierra Leone
Grenada	Somalia
Guatemala	Switzerland
Haiti	Syrian Arab Republic
Ivory Coast	Togo
Jamaica	Tonga
Jordan <sup>a/</sup>	Tunisia
Kenya	United Republic of Cameroon
Lao People's Democratic Republic	Upper Volta
Liberia	Venezuela

<sup>a/</sup> At the date of publication of the annual report for 1977, the safeguards agreements with Afghanistan and Jordan had entered into force.

182. At the end of 1977, according to information available to the Agency, there were significant nuclear facilities in 13 non-nuclear-weapon States not party to NPT. These were: Argentina, Brazil, Chile, Colombia, Democratic People's Republic of Korea, Egypt, India, Indonesia, Israel, Pakistan, South Africa, Spain and Turkey. The Agency was applying safeguards in 12 of these States, excluding Egypt, and in the case of eight States, according to the information available to the Agency, all nuclear activities involving significant quantities of special fissionable material were covered by those safeguards. The five exceptions were Egypt, India, Israel, South Africa and Spain. Egypt, however, had signed but not yet ratified NPT.

183. In 1977 the Agency applied safeguards to significant nuclear activities in 30 States under NPT agreements and in 20 States under non-NPT agreements.

184. During 1977 the Board approved:

- (a) In connection with NPT, safeguards agreements with the Maldives, San Marino, Senegal, Sierra Leone, and Singapore;
- (b) In connection with NPT and the Tlatelolco Treaty, a safeguards agreement with Paraguay;
- (c) Unilateral Submission Agreements between:

The Agency and Argentina to cover equipment supplied by the Federal Republic of Germany;

The Agency and Argentina to cover nuclear and non-nuclear material, equipment and facilities supplied under a co-operation agreement between Argentina and Canada on the development and application of atomic energy for peaceful purposes;

The Agency and the Democratic People's Republic of Korea to cover a research reactor and the fuel for that reactor supplied by the Soviet Union;

The Agency and India to cover nuclear and non-nuclear material and facilities as a result of a supply of heavy water from the Soviet Union; and

The Agency and Pakistan to cover a supply of uranium concentrate from Niger.

185. During 1977 the Agency carried out 706 inspections in 45 States (343 in connection with NPT), compared with 565 inspections (228 in connection with NPT) in 40 States during the preceding year. Of the 706 inspections, 283 were made of power plants, 117 of bulk fuel plants and 306 of other facilities including research reactors. In addition, two reprocessing plants were under continuous inspections, in which no safeguards were implemented in 1976.

186. At the end of 1977, 100 individual Safeguards Implementation Practices (SIPs) had been issued, achieving consistency of inspection procedures in respect of nuclear facilities where nuclear material was under safeguards. A further 92 SIPs were under preparation.

187. The NPT Safeguards Agreement with EURATOM and the non-nuclear-weapon Member States of EURATOM entered into force on 21 February 1977. The preparation of facility attachments made progress.

188. The NPT Safeguards Agreement with Japan entered into force on 2 December 1977.

189. Table 5 shows the quantities of nuclear material that were under Agency safeguards at the end of the year indicated.

Table 5

## Quantities of nuclear material under Agency safeguards

Material	Amounts by years				
	1973	1974	1975	1976	1977
<u>Plutonium (kg)</u>					
(a) Contained in irradiated fuels	2 927	4 345	6 661	11 775	12 297 <sup>a/</sup>
(b) In other forms	1 443	1 955	2 374	2 778	5 715
(c) Total	4 730	6 300	9 035	14 553	18 012 <sup>a/</sup>
<u>Uranium enriched to more than 20% (kg)</u>					
Contained in irradiated fuels:					
(a) Fissile content	1 157	1 275	1 445	1 245	2 903
(b) Total element	2 812	2 942	3 422	2 115	5 346
In other forms:					
(a) Fissile content	380	455	471	529	2 984
(b) Total element	556	668	791	864	5 825
<u>Uranium enriched to less than 20% (kg)</u>					
Contained in irradiated fuels:					
(a) Fissile content	27 808	36 865	44 892	47 376	93 014
(b) Total element	1 342 336	1 729 491	2 273 629	2 275 334	4 664 116
In other forms:					
(a) Fissile content	13 801	14 718	19 926	32 887	96 271
(b) Total element	519 579	571 947	817 948	1 337 763	3 185 201
<u>Uranium enriched, Totals (tonnes)</u>					
(a) Fissile content	43	53	67	82	194
(b) Total element	1 865	2 305	3 096	3 649	7 860
<u>Source material (tonnes)</u>	3 370	3 910	4 440	5 336	12 234

<sup>a/</sup> These figures represent only plutonium reported to the Agency by the States. In addition to this, 18 764 kg of plutonium (as calculated by the Agency on the basis of published data) contained in reactor cores and reactor cooling ponds are not reported to the Agency because such reporting is not specified in some safeguards agreements/subsidiary arrangements. The item accounting and containment and surveillance measures are applied to this non-reported plutonium.

190. A list of nuclear installations under Agency safeguards, or containing material safeguarded, is given in Table 6.

Table 6

Nuclear installations under Agency safeguards, or  
containing material safeguarded

Nuclear installations	End of 1977	
	NPT	Non-NPT
Power reactors	78	22
Conversion and fuel fabrication plants	21	2
Enrichment plants	1	0
Reprocessing plants	3	0
Pilot fuel fabrication plants	11	2
Pilot enrichment plants	2	0
Pilot reprocessing plants	1	1
Research reactors and critical facilities	135	34
Sub-critical facilities	15	1
Research and development facilities	39	1
Other locations	180	10
	<u>486</u>	<u>73</u>

Safeguards development and technical support

191. The use of portable non-destructive assay (NDA) instrumentation for safeguards purposes significantly increased as a result of the development and field testing of new measurement techniques employing high resolution gamma-ray spectroscopic and neutron coincidence systems. A Member State developed a new portable high level neutron coincidence counter for the Agency. This instrument was successfully used for plutonium verification. The Agency also used gamma-ray spectroscopy for the assay of UF<sub>6</sub> storage cylinders and irradiated fuel.

192. There was further developmental work to ensure faster processing of NDA measurement data brought to Headquarters on magnetic tapes. To accomplish this, a new multi-channel analyser was installed and applied. The Agency held two advisory group meetings during 1977 to provide direction for future developmental effort in NDA methods and techniques. These meetings concerned the application of NDA for irradiated fuel assemblies and the use of physical standards in inspection and measurements of nuclear materials by non-destructive techniques.

193. The first results from the safeguards support programmes offered to the Agency by Canada, the Federal Republic of Germany and the United States of America significantly improved Agency safeguards activities.

194. The Agency made further progress in the development of surveillance techniques. A number of improvements were made to TV surveillance systems and further projects were under way to improve the video magnetic recording techniques, especially with respect to reliability. The Agency has started to use the basic TV system model for routine inspection activities. A more advanced version of the film camera was developed and put into use.

Development of prototype self-monitoring seals which can be verified by telephone was undertaken. Samples of all the above-mentioned instruments were displayed at the General Conference. Processing and read-out instrumentation for track-etch reactor power monitors was made available to the Agency.

195. The third annual research co-ordination meeting on isotopic correlation techniques and data bank was held in Vienna in October 1977 in which the participants discussed the practical safeguards application of the techniques during a reprocessing campaign.

196. The cost of safeguards research contracts awarded in 1977 amounted to about \$1 298 000 of which the Agency's financial contribution was only \$261 000.

197. An advisory group meeting on safeguarding uranium enrichment facilities was held in Tokyo in March, with participation from eight Member States and EURATOM. The group recommended a safeguards approach for facilities using the ultracentrifuge process. The problems inherent in safeguarding enrichment facilities using other processes (notably the gaseous diffusion process) were discussed.

198. The Agency continued its efforts to assist Member States to develop satisfactory national systems of nuclear materials accounting and control. In addition, the Agency developed guidelines for the provision of individualized "nuclear expert" assistance to Member States, and under those guidelines made two visits to one Member State.

199. Since the quantity of discharged fuel stored at reactors is increasing, a study was made to estimate the quantity of plutonium which is subject to Agency safeguards but which is not reflected in materials accountancy reports. [5]

200. The Agency devoted considerable effort to the preparation of working documents on safeguards for reprocessing facilities. With the assistance of Canadian experts it also prepared a comprehensive study of safeguards for CANDU-type reactors.

201. In order to prepare a complete set of model safeguards documentation for different types of nuclear facilities the Agency carried out an integral safeguards exercise at a large LWR fuel fabrication plant. A similar exercise was begun for a reprocessing facility.

202. The Agency established a Technical Service Section in May 1977 to centralize procurement, maintenance and calibration of instruments and equipment needed for inspections in the field.

203. The work load of the Safeguards Analytical Laboratory (SAL) was lower than originally projected, and only about 350 inspection samples were analysed during 1977. SAL participated in the characterization of NDA standards, and worked towards the implementation of a method of analysing reprocessing plant input solutions using only nanogram quantities of material, thus making the otherwise difficult shipment of samples possible. Also, in conjunction with the analysis of reprocessing input solutions, SAL prepared 300 isotope reference standards.

#### Safeguards information treatment

204. In spring 1977, the Safeguards Information Treatment Unit was transformed into the Division of Safeguards Information Treatment (DSIT) which, according to its functions, was organized in three Sections: for Data Processing Operations; for Data Processing Development; and for Data Evaluation Services.

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[5] See Table 5.

205. The amounts of incoming records and cumulative number of records in the Safeguards Information System are shown below:

Table 7

Year	1975	1976	1977
Number of accounting records received during the year	25 000	30 000	117 813
Cumulative number of records in Safeguards Information System	30 150	87 690 <sup>a/</sup>	205 523

a/ Including the backlog of records received in previous years.

206. In September 1977, the "Remote Job Entry" station was installed to ensure confidentiality of safeguards information. This allows remote entry of computer jobs, and the possibility of returning results on the terminal printer.

207. The newly formed Data Evaluation Services Section assisted the inspectorate in preparing and performing inspections and in evaluating results from these inspections.

208. A data base management system, ADABAS, donated by the Federal Republic of Germany, was installed and made operational as a major part of the IAEA safeguards information system.

209. Flexible formats for reporting on magnetic tape were developed. Using these formats, nuclear materials accountancy reports were structured and transmitted to the Agency for one large United States facility. These data were loaded into the Agency safeguards data base as a test of new software and procedures under development.

210. The conceptual design of an expanded safeguards information system was completed and detailed flow charting, programming, documentation and testing of parts of the system were carried out.

211. The advisory group meeting on sample transport and measurement capabilities of the Agency's network of analytical laboratories (PAFEX I and II) was held in November.

212. Various evaluation services were provided, such as design and evaluation of experiments for the characterization of standards for non-destructive measurement, calibration of reprocessing plant vessels, application of isotope correlation techniques in reprocessing plants, calculation of sample plans, and development of other statistical procedures.

213. Part F, Volume 1, of the Safeguards Technical Manual on Statistical Concepts and Techniques was completed and issued during 1977.

#### Standardization and administrative support

214. Further work was done on standardizing the Subsidiary Arrangements required for NPT safeguards agreements especially with respect to reports to be submitted by operators. The reporting requirements were also reformulated for those States which might wish to transmit such reports on magnetic tape.

215. A generalized model of the Subsidiary Arrangements required for non-NPT agreements was prepared. This is designed to eliminate differences in the reporting procedures and thereby simplify the handling of these reports and make it possible to standardize computer operations.

#### Safeguards evaluation

216. In June 1977 a Section for the evaluation of the effectiveness of safeguards activities was established. Until the end of 1977, the new Section reviewed 214 inspection reports as well as 30 statements on safeguards conclusions in relation to non-NPT safeguards agreements, 145 statements on safeguards results and 20 statements on safeguards conclusions in connection with NPT safeguards agreements to the States concerned.

#### Safeguards training

217. Two introductory courses on Agency safeguards were held at which newly recruited inspectors received basic training in safeguards matters.

218. Agency staff members attended a training seminar held in the Soviet Union.

219. Personnel from 18 developing countries participated in a study tour on technical aspects of safeguards and control of nuclear material, which was held in Czechoslovakia, the German Democratic Republic and the Soviet Union.

220. The Agency's basic training course for staff of national systems of accounting for and control of nuclear material was repeated for personnel from 22 States.

221. Two workshop seminars were conducted for Member States which must contribute safeguards data to the Agency in compliance with NPT-type and non-NPT-type safeguards agreements, and 23 States sent 44 participants.

Table 8

Situation on 31 December 1977 with respect to the signature of, ratification of, or accession to, NPT by non-nuclear-weapon States, and the conclusion of safeguards agreements between the Agency and these States in connection with NPT

Non-nuclear-weapon States which have signed, ratified or acceded to NPT <sup>a/</sup> (1)	Date of ratification or accession <sup>a/</sup> (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Afghanistan	4 February 1970	Signed: 24 April 1977	
Australia	23 January 1973	In force: 10 July 1974	217
Austria	28 June 1969	In force: 23 July 1972	156
Bahamas	10 July 1973	Under negotiation	
Barbados		Under negotiation	
Belgium	2 May 1975	In force: 21 February 1977	193
Benin	31 October 1972		
Bolivia <sup>b/</sup>	26 May 1970	Signed: 23 August 1974	
Botswana	28 April 1969	Under negotiation	
Bulgaria	5 September 1969	In force: 29 February 1972	178
Burundi	19 March 1971	Under negotiation	
Canada	8 January 1969	In force: 21 February 1972	164
Central African Empire	25 October 1970	Under negotiation	
Chad	10 March 1971	Under negotiation	
China, Republic of	27 January 1970	Negotiations discontinued	
Colombia		Under negotiation	
Costa Rica <sup>b/</sup>	3 March 1970	Signed: 12 July 1973	
Cyprus	16 February 1970	In force: 26 January 1973	189
Czechoslovakia	22 July 1969	In force: 3 March 1972	173
Democratic Kampuchea	2 June 1972		
Democratic Yemen			
Denmark <sup>c/</sup>	3 January 1969	In force: 21 February 1977	193
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			
El Salvador <sup>b/</sup>	11 July 1972	In force: 22 April 1975	232
Ethiopia	5 February 1970	In force: 2 December 1977	
Fiji	14 July 1972	In force: 22 March 1973	192
Finland	5 February 1969	In force: 9 February 1972	155
Gabon	19 February 1974	Approved by the Board	
Gambia	12 May 1975		
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	11 March 1970	Provisionally in force: 1 March 1972	166
Grenada	19 August 1974	Under negotiation	
Guatemala	22 September 1970	Under negotiation	
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			
Iran	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
Ivory Coast	6 March 1973		
Jamaica	5 March 1970	Under negotiation	
Japan	8 June 1976	In force: 2 December 1977	255
Jordan	11 February 1970	Signed: 5 December 1974	
Kenya	11 July 1970	Under negotiation	
Korea, Republic of	23 April 1975	In force: 14 November 1975	236
Kuwait			
Lao People's Democratic Republic	20 February 1970	Under negotiation	

(1)	(2)	(3)	(4)
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	Under negotiation	
Luxembourg	2 May 1975	In force: 21 February 1977	193
Madagascar	8 October 1970	In force: 14 June 1973	200
Malaysia	5 March 1970	In force: 29 February 1972	182
Maldives	7 April 1970	In force: 2 October 1977	253
Mali	5 March 1970	Under negotiation	
Malta	6 February 1970	Under negotiation	
Mauritius	28 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
Morocco	30 November 1970	In force: 18 February 1975	228
Nepal	5 January 1970	In force: 22 June 1972	186
Netherlands <sup>d/</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	Under negotiation	
Norway	5 February 1969	In force: 1 March 1972	177
Panama	13 January 1977	Under negotiation	
Paraguay <sup>b/</sup>	4 February 1970	Approved by the Board	
Peru	3 March 1970	Under negotiation	
Philippines	5 October 1972	In force: 16 October 1974	216
Poland	12 June 1969	In force: 11 October 1972	179
Portugal	15 December 1977		
Romania	4 February 1970	In force: 27 October 1972	180
Rwanda	20 May 1975		
Samoa	18 March 1975	Under negotiation	
San Marino	10 August 1970	Approved by the Board	
Senegal	17 December 1970	Approved by the Board	
Sierra Leone	26 February 1975	Signed: 10 November 1977	
Singapore	10 March 1976	In force: 18 October 1977	
Somalia	5 March 1970	Under negotiation	
Sri Lanka			
Sudan	31 October 1973	In force: 7 January 1977	245
Surinam <sup>d/</sup>	30 June 1976	In force: 5 June 1975	230
Swaziland	11 December 1969	In force: 28 July 1975	227
Sweden	9 January 1970	In force: 14 April 1975	234
Switzerland	9 March 1977	Under negotiation	
Syrian Arab Republic	24 September 1969	Under negotiation	
Thailand	7 December 1972	In force: 16 May 1974	241
Togo	26 February 1970		
Tonga	7 July 1971	Approved by the Board	
Trinidad and Tobago			
Tunisia	26 February 1970	Under negotiation	
Turkey			
United Republic of Cameroon	8 January 1969	Under negotiation	
Upper Volta	3 March 1970	Under negotiation	
Uruguay <sup>b/</sup>	31 August 1970	In force: 17 September 1976	157
Venezuela	26 September 1975	Under negotiation	
Yemen Arab Republic			
Yugoslavia	3 March 1970	In force: 28 December 1973	204
Zaire	4 August 1970	In force: 9 November 1972	183

a/ The information reproduced in columns (1) and (2) was provided to the Agency by the 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. Viet Nam is reconsidering adherence to the commitments of the former Administration under international agreements.

b/ The relevant safeguards agreement was concluded in connection with both NPT and the Tlatelolco Treaty.

c/ The NPT safeguards agreement with Denmark (INFCIRC/176), in force since 1 March 1972, has been replaced by the agreement of 5 April 1973 between the seven non-nuclear-weapon States of EURATOM, EURATOM and the Agency (INFCIRC/193) but still applies to the Faroe Islands.

d/ Agreements have also been concluded in respect of the Netherlands Antilles (INFCIRC/229) and Surinam, under NPT and Additional Protocol I to the Tlatelolco Treaty. These agreements entered into force on 5 June 1975. Surinam attained independence on 25 November 1975. By letter of 30 June 1976 the Government of Surinam notified the Government of the United States of America of Surinam's succession to NPT.

Table 9

Agreements providing for safeguards other than those  
in connection with NPT,  
approved by the Board as of 31 December 1977

Party(ies) <sup>a/</sup>	Subject	Entry into force	INFCIRC
<u>Bilateral Agreements</u>			
(a) Project Agreements			
Argentina	Siemens SUR-100 RAEP Reactor	13 Mar 1970 2 Dec 1964	143 62
Chile	Herald Reactor	19 Dec 1969	137
Finland <sup>b/</sup>	FIR-1 Reactor	30 Dec 1960	24
	FINN sub-critical assembly	30 Jul 1963	53
Greece <sup>b/</sup>	GRR-1 Reactor	1 Mar 1972	163
Indonesia	Additional core-load for Triga Reactor	19 Dec 1969	136
Iran <sup>b/</sup>	UTRR Reactor	10 May 1967	97
Japan <sup>b/</sup>	JRR-3	24 Mar 1959	3
Mexico <sup>b/</sup>	TRIGA-III Reactor	18 Dec 1963	52
	Siemens SUR-100	21 Dec 1971	162
	Laguna Verde Nuclear Power Plant	12 Feb 1974	203
Pakistan	PRR Reactor	5 Mar 1962	34
	Booster rods for KANUPP	17 Jun 1968	116
Philippines <sup>b/</sup>	PRR-1 Reactor	28 Sep 1966	88
Romania <sup>b/</sup>	TRIGA Reactor	30 Mar 1973	206
Spain	Coral 1 Reactor	23 Jun 1967	99
Turkey	Sub-critical assembly	17 May 1974	212
Uruguay <sup>b/</sup>	URR Reactor	24 Sep 1965	67
Venezuela	RV-1 Reactor	7 Nov 1975	238
Yugoslavia <sup>b/</sup>	TRIGA-II	4 Oct 1961	32
	KRSKO Nuclear Power Plant	14 Jun 1974	213
Zaire <sup>b/</sup>	TRICO Reactor	27 Jun 1962	37
(b) Unilateral submissions			
Argentina	Atucha Power Reactor Facility	3 Oct 1972	168
	Nuclear material	23 Oct 1973	202
	Embalse Power Reactor Facility	6 Dec 1974	224
	Equipment	22 Jul 1977	250
	Nuclear material, equipment and facilities	22 Jul 1977	251
Chile	Nuclear material	31 Dec 1974	
China, Republic of	Taiwan Research Reactor Facility	13 Oct 1969	133
Democratic People's Republic of Korea	Research reactor and nuclear material for this reactor	20 Jul 1977	252
India	Nuclear and non-nuclear material facilities	17 Nov 1977	
Mexico <sup>b/</sup>	All nuclear activities	6 Sep 1968	118
Pakistan	Nuclear material	2 Mar 1977	248
Panama <sup>c/</sup>	All nuclear activities		
Spain	Nuclear material	19 Nov 1974	218
	Nuclear material	18 Jun 1975	221
Switzerland	Nuclear material		
United Kingdom	Nuclear material	14 Dec 1972	175

Party(ies) <sup>a/</sup>	Entry into force	INFCIRC
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Trilateral Agreements

(While the Agency is a party to each of the following agreements, the list only mentions the States party to them)

Argentina/United States of America	25 Jul 1969	130
Australia <sup>b/</sup> /United States of America	26 Sep 1966	91
Austria <sup>b/</sup> /United States of America	24 Jan 1970	152
Brazil/Germany, Federal Republic of <sup>b/</sup>	26 Feb 1976	237
Brazil/United States of America	20 Sep 1972	110
China, Republic of/United States of America	6 Dec 1971	158
Colombia/United States of America	9 Dec 1970	144
India/Canada <sup>b/</sup>	30 Sep 1971	211
India/United States of America	27 Jan 1971	154
Indonesia/United States of America	6 Dec 1967	109
Iran <sup>b/</sup> /United States of America	20 Aug 1969	127
Israel/United States of America	4 Apr 1975	249
Japan <sup>b/</sup> /Canada <sup>b/</sup>	12 Nov 1969	85
Japan <sup>b/</sup> /France	22 Sep 1972	171
Japan/United States of America	10 Jul 1968	119
Japan <sup>b/</sup> /United Kingdom	15 Oct 1968	125
Japan <sup>b/</sup> /Australia <sup>b/</sup>	28 Jul 1972	170
Korea, Republic of/United States of America	19 Mar 1973	111
Korea, Republic of <sup>b/</sup> /France	22 Sep 1975	233
Pakistan/Canada	17 Oct 1969	135
Pakistan/France	18 Mar 1976	239
Philippines <sup>b/</sup> /United States of America	19 Jul 1968	120
Portugal/United States of America	19 Jul 1969	131
South Africa/United States of America	28 Jun 1974	98
South Africa/France	5 Jan 1977	244
Spain/United States of America	28 Jun 1974	92
Spain/Canada <sup>b/</sup>	10 Feb 1977	247
Sweden <sup>b/</sup> /United States of America	1 Mar 1972	165
Switzerland/United States of America	28 Feb 1972	161
Turkey/United States of America	5 Jun 1969	123
Venezuela/United States of America	27 Mar 1968	122

a/ An entry in this column does not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities or concerning the delimitation of its frontiers. The Socialist Republic of Viet Nam is reconsidering adherence to the commitments of the former Administration under international agreements.

b/ Application of Agency safeguards under this agreement has been suspended as the State has concluded an agreement in connection with NPT.

c/ At present Panama has no significant nuclear activities. The agreement is concluded under Article 13 of the Tlatelolco Treaty.

Table 10

Nuclear installations under Agency safeguards or containing  
safeguarded material under agreements approved by the  
Board of Governors

## A. Research reactors and critical facilities

State <sup>a/</sup>	Abbreviated name	Location	Type	Capacity MW(th)	In operation
Argentina	RA-0	Cordoba	Tank	0.00	
	RA-1	Constituyentes	Argonaut	0.12	x
	RA-2	Constituyentes	Argonaut	0.03	x
	RA-3	Ezeiza	Pool-tank	5.00	x
	RA-4	Rosario	Solid-homogeneous	0.00	x
Australia <sup>b/</sup>	HIFAR	Lucas Heights, N. S. W.	Tank	11.00	x
	MOATA	Lucas Heights, N. S. W.	Argonaut	0.01	x
	CF	Lucas Heights, N. S. W.	Critical Facility	0.00	x
Austria <sup>b/</sup>	SAR	Graz	Argonaut	0.01	x
	TRIGA-VIENNA	Vienna	Triga II	0.25	x
	ASTRA	Seibersdorf	Pool	12.00	x
Belgium <sup>b/</sup>	BR1-CEN	Mol	Tank	4.00	x
	BR2-CEN	Mol	Tank	100.00	x
	Thetis	Gent	Pool	0.15	x
	BRO2-CEN	Mol	Tank	0.00	x
	CEN-Venus	Mol	Tank	0.00	x
Brazil	IEA-R1	São Paulo	Pool	5.00	x
	IPR-R1	Belo Horizonte	Triga I	0.10	x
	RIEN.1	Rio de Janeiro	Argonaut	0.01	x
Bulgaria <sup>b/</sup>	IRT-2000	Sofia	Pool	2.00	x
Canada <sup>b/</sup>	NRX	Chalk River, Ont.	NRX	30.00	x
	NRU	Chalk River, Ont.	NRU	125.00	x
	WR-1	Pinawa, Manitoba	Organic-cooled	60.00	x
	McMaster	Hamilton, Ont.	Pool-type	2.5	x
	Slowpoke - Toronto	Univ. of Toronto	Pool-type	0.02	x
	Slowpoke - Ottawa	Ottawa, Ont.	Pool-type	0.02	x
	PTR	Chalk River, Ont.	Pool-type	0.00	x
	ZED-2	Chalk River, Ont.	Pool-type	0.00	x
	ZEEP	Chalk River, Ont.	Tank	0.00	x
	Slowpoke - Halifax	Dalhousie Univ,	Pool-type	0.02	x
	Slowpoke - Montreal	Ecole Poly.	Pool-type	0.02	x
	Slowpoke - Edmonton	Univ. of Alberta	Pool-type	0.02	x
	Chile	Herald	Santiago	Herald	5.00
MTR		Lo Aguirre	Pool	10.00	x
China, Republic of	THOR	Hsin-chu	Pool	1.00	x
	TRR	Huaitzupu	NRX	40.00	x
	ZPRL	Lung-Tan	Pool	0.01	x
	THAR	Hsin-chu	Argonaut	0.01	x
	MER	Hsin-chu	Mobile Educational Reactor	0.00	x
Colombia	IAN-R1	Bogotá	Pool-type	0.02	x
Czechoslovakia <sup>b/</sup>	SR-OD	Pilsen	Pool	0.00	x
	VVR-S	Rez	Tank	10.00	x
	TR-O	Rez	Tank	0.00	x
Democratic People's Republic of Korea	IRT (modified)		Pool-tank	2.00	x
Denmark <sup>c/</sup>	DR-1	Risø	Homogeneous	0.00	x
	DR-3	Risø	Tank	10.00	x
Finland <sup>b/</sup>	FiR-1	Otanemi	Triga II	0.25	x
German Democratic Republic <sup>b/</sup>	WWR-S(M)	Rossendorf	Tank	10.00	x
	RRR and RAKE	Rossendorf	Tank	0.00	x

State <sup>a/</sup>	Abbreviated name	Location	Type	Capacity MW(th)	In operation	
Germany, Federal Republic of <sup>b/</sup>	FRM	Garching	Pool	4,00	x	
	GKSS-FRG1	Geesthacht	Pool	5,00	x	
	GKSS-FRG2	Geesthacht	Pool	15,00	x	
	FRF	Frankfurt	Aqueous Homogeneous	0,05	x	
	GFK-FR-2	Karlsruhe	Tank	45,00	x	
	KWU-PR10	Karlstein	Argonaut	0,00	x	
	KFA-FRJ1	Jülich	Pool	10,00	x	
	KFA-FRJ2	Jülich	Tank	23,00	x	
	Triga	Mainz	Triga I	0,10	x	
	Triga 1	Heidelberg	Triga I	0,25	x	
	Triga 2	Heidelberg	Triga II	0,25	x	
	FMRB	Braunschweig	Tank	1,00	x	
	Triga	Hanover	Triga II	0,25	x	
	Triga	Neuherberg	Triga II	1,00	x	
	GFK-SNEAK	Karlsruhe	Critical assembly	0,00	x	
	KFA-KAHTER	Jülich	Critical assembly	0,00	x	
	ADIBKA	Jülich	Aqueous Homogeneous	0,00	x	
	SUR 100	Garching	Solid-homogeneous	0,00	x	
	SUR 100	Darmstadt	Solid-homogeneous	0,00	x	
	SUR 100	Stuttgart	Solid-homogeneous	0,00	x	
	SUR 100	Hamburg	Solid-homogeneous	0,00	x	
	SUR 100	Kiel	Solid-homogeneous	0,00	x	
	SUR 100	Ulm	Solid-homogeneous	0,00	x	
	SUR 100	Karlsruhe	Solid-homogeneous	0,00	x	
	SUR 100	Bremen	Solid-homogeneous	0,00	x	
	SUR 100	Furtwang	Solid-homogeneous	0,00	x	
	SUR 100	Aachen	Solid-homogeneous	0,00	x	
	KFA-ITR	Jülich	Critical assembly	0,00	x	
	KWU	Karlstein	Critical assembly	0,00	x	
		BER-2	Berlin (West)	Aqueous Homogeneous	5,00	x
		SUR 100	Berlin (West)	Solid-homogeneous	0,00	x
	Greece <sup>b/</sup>	GRR-1	Athens	Pool	5,00	x
	Hungary <sup>b/</sup>	WWR-SM	Budapest	Pool	5,00	x
		ZR-4 and ZR-6	Budapest	Pool	0,00	x
		Training reactor	Budapest	Pool	0,01	x
	Indonesia	PRAB (TRIGA II)	Bandung	Triga II	1,00	x
	Iran <sup>b/</sup>	TSPRR	Teheran	Pool	5,00	x
	Iraq <sup>b/</sup>	IRT-2000	Baghdad	Pool	2,00	x
	Israel	IRR-1	Soreq	Pool	5,00	x
	Italy <sup>b/</sup>	Triga 1-RC1	Casaccia	Triga I	1,00	x
AGN-201		Palermo	Solid-homogeneous	0,00	x	
CESNEF-L54		Milan	Aqueous Homogeneous	0,05	x	
ESSOR		Ispra	Tank	40,00	x	
RTS-1-S, Pl, A		Pisa	Pool	5,00	x	
RANA		Casaccia	Pool	0,01	x	
RB-2		Montecucco	Argonaut	0,01	x	
RITMO		Casaccia	Pool	0,00	x	
TAPIRO		Casaccia	Fast neutron	0,00	x	
Triga 2		Pavia	Triga II	0,25	x	
ROSPO		Casaccia	Tank	0,00	x	
RB-1		Montecucco	Graphite	0,00	x	
RB-3		Montecucco	Tank (D <sub>2</sub> O)	0,01	x	
Japan		AHCF <sup>*/</sup>	Tokai-Mura	Critical Facility	0,00	x
	DCA	Oarai-Machi	Critical Facility	0,00	x	
	FCA	Tokai-Mura	Critical Facility	0,01	x	
	HCF	Ozenji	Critical Facility	0,00	-	
	HTR	Kawasaki-shi	Pool	0,10	x	
	JMTR	Oarai-Machi	Tank	50,00	x	
	JMTR-CA	Oarai-Machi	Critical Facility	0,00	x	
	JOYO	Oarai	EBR	50,00	-	
	JPDR	Tokai-Mura	Boiling-water	90,00	x	
	JRR-2	Tokai-Mura	Tank	10,00	x	
	JRR-3	Tokai-Mura	Tank	10,00	x	
	JRR-4	Tokai-Mura	Pool	1,00	x	
	Kinki University	Kowakai	UTR-B	0,00	x	
	KUR	Kumatori-cho	Pool	5,00	x	
	KUCA	Kumatori-cho	Critical Facility	0,00	x	
	NSRR	Tokai-Mura	Triga (pulse)	0,3	-	

<sup>\*/</sup> Dismantled; fuel still at facility.

State <sup>a/</sup>	Abbreviated name	Location	Type	Capacity MW(th)	In operation
	Musashi College of Technology	Kawasaki-shi	Triga II	0,10	x
	NAIG-CA	Kawasaki-shi	Critical Facility	0,00	x
	Rikkyo University	Nagasaki	Triga II	0,10	x
	SHCA	Tokai-Mura	Critical Facility	0,00	x
	TCA	Tokai-Mura	Critical Facility	0,00	x
	TODAI	Tokai-Mura	Fast Neutron Source Reactor	0,002	x
	TTR	Kawasaki-shi	Pool	0,10	x
	"Mutsu" (Nuclear Ship)	Minato-Machi Mutsu	PWR	36,00	x
Korea, Republic of <sup>b/</sup>	KRR - TRIGA II	Seoul	Triga II	0,10	x
	KRR - TRIGA III	Seoul	Triga III	2,00	x
Mexico <sup>d/</sup>	Centro Nuclear de Mexico	Ocoyoacac	Triga III	1,00	x
	Training reactor facility	Mexico City	SUR-100	0,00	x
Netherlands <sup>b/</sup>	LFR	Petten	Argonaut	0,01	x
	HOR-THS	Delft	Pool	2,00	x
	BARN	Wageningen	Graphite	0,10	x
	KEMA	Arnhem	Aqueous Homogeneous	1,00	x
	HFR	Petten	Tank	45,00	x
	DELPHY	Delft	Critical assembly	-	-
Norway <sup>b/</sup>	JEEP-II	Kjeller	Tank	2,00	x
	HBWR	Halden	HBWR	25,00	x
Pakistan	PARR	Rawalpindi	Pool	5,00	x
Philippines <sup>b/</sup>	PRR-1	Diliman, Quezon City	Pool	1,00	x
Poland <sup>b/</sup>	EWA	Świerk	Tank	8,00	x
	Anna	Świerk	Graphite	0,00	x
	Agata	Świerk	Pool	0,00	x
	Maria	Świerk	Tank	30,00	x
Portugal	RPI	Sacavem	Tank	1,00	x
Romania <sup>b/</sup>	VVR-S	Margurele	Tank	10,00	x
	RP-01	Margurele	Critical Facility	0,00	-
South Africa	SAFARI-1	Pelindaba	Tank	20,00	x
Spain	JEN-1 and JEN-2	Madrid	Pool	3,00	x
	CORAL-1	Madrid	Fast Critical Facility	0,00	x
	ARBI	Bilbao	Argonaut	0,01	x
	ARGOS	Barcelona	Argonaut	0,01	x
Sweden <sup>b/</sup>	R2	Studsvik	Tank	50,00	x
	R2-O	Studsvik	Pool	1,00	x
	KRITZ	Studsvik	Pool	0,00	x
	R-O	Studsvik	Pool	0,00	x
Switzerland	Proteus	Würenlingen	Critical Facility	0,00	x
	Saphir	Würenlingen	Pool	5,00	x
	Diorit	Würenlingen	HW	30,00	x
	Crocus	Lausanne	Pool	1,00	x
	AGN201P	Geneva	Solid-homogeneous	0,00	x
	AGN211P	Basel	Pool	0,00	x
Thailand <sup>b/</sup>	TRR-1	Bangkok	Pool	2,00	x
Turkey	TR-1	Istanbul	Pool	1,00	x
United Kingdom	Zebra	Winfrith	Critical Facility	0,00	x
Uruguay <sup>b/</sup>	RUDI	Montevideo	Lockheed	0,10	-
Venezuela	RVI	Alto de Pipe	Pool	3,00	x
Yugoslavia <sup>b/</sup>	Triga II	Ljubljana	Triga II	0,25	x
	Boris Kidric R.	Vinča	Pool	6,50	x
	RB	Vinča	Critical assembly	0,00	x
Zaire <sup>b/</sup>	Triga	Kinshasa	Triga II	1,00	x

B. Nuclear power reactors

State <sup>a/</sup>	Name of power reactor	Location	Type	Capacity MW(e)	In operation
Argentina	Atucha Nuclear Power Station	Atucha	PHWR	319	x
	Embalse	Cordoba	Candu	600	-
Austria <sup>b/</sup>	Tullnerfeld	Zwentendorf	PWR	700	-
Belgium <sup>b/</sup>	BR-3-CEN-Mol	Mol	PWR	11	x
	DOEL-1-Antwerp	Antwerp	PWR	412	x
	DOEL-2-Antwerp	Antwerp	PWR	412	x
	SEMO-Tihange	Tihange	PWR	920	x
Brazil	Angra-1	Angra dos Reis	PWR	975	-
Bulgaria <sup>b/</sup>	Kozloduy 1	Kozloduy	PWR	880	x
Canada <sup>b/</sup>	Bruce-1	Tiverton, Ontario	Candu	788	x
	Bruce-2	Tiverton, Ontario	Candu	788	x
	Bruce-3	Tiverton, Ontario	Candu	788	x
	Bruce-4	Tiverton, Ontario	Candu	788	-
	DPGS	Kincardine, Ontario	Candu	208	x
	Gentilly-1	Gentilly, Quebec	Candu	250	x
	Gentilly-2	Gentilly, Quebec	Candu	600	-
	NPD	Ralphton, Ontario	Candu	22	x
	Pickering-1	Pickering, Ontario	Candu	540	x
	Pickering-2	Pickering, Ontario	Candu	540	x
	Pickering-3	Pickering, Ontario	Candu	540	x
	Pickering-4	Pickering, Ontario	Candu	540	x
China, Republic of	FNPS-1	Ching-San	BWR	636	x
	FNPS-2	Ching-San	BWR	636	-
Czechoslovakia <sup>b/</sup>	A1	Bohunice	HWGC	143	x
Finland <sup>b/</sup>	Loviisa	Loviisa	PWR	880	x
German Democratic Republic <sup>b/</sup>	Rheinsberg PWR	Rheinsberg	PWR	80	x
	Bruno Leuschner PWR-1	Greifswald	PWR	880	x
	Bruno Leuschner PWR-2	Greifswald	PWR	440	x
Germany, Federal Republic of <sup>b/</sup>	KRB-1-Gundremmingen	Gundremmingen	BWR	250	x
	GFK-MZFR-Karlsruhe	Karlsruhe	PWR	58	x
	VAK-KAHL-Grosswelzheim	Grosswelzheim	BWR	16	x
	AVR-Jülich	Jülich	HTGR	15	x
	KWL-1-Lingen	Lingen	BWR	267	x
	KNK-Karlsruhe	Karlsruhe	SZR	21	x
	KWW-Wurgassen	Wurgassen	BWR	670	x
	KKS-Stade-1-HAM	Stade	PWR	662	x
	KWO-Obrigheim	Obrigheim	PWR	345	x
	KKB-Brunsbüttel	Brunsbüttel	BWR	805	x
	RWE-BIBLIS-A	Biblis	PWR	1204	x
	RWE-BIBLIS-B	Biblis	PWR	1300	x
	GKN-Neckarwestheim	Neckarwestheim	PWR	805	x
	KKU-Unterweser	Unterweser	PWR	1300	x
	KKI-ISAR	Ohu	BWR	907	x
	GKSS-Geesthacht	Geesthacht	BWR	12	x
KKP-Philippsburg	Philippsburg	BWR	907	x	
India	Tarapur-1	Tarapur	BWR	190	x
	Tarapur-2	Tarapur	BWR	190	x
	Rajasthan-1	Rajasthan	Candu	200	x
	Rajasthan-2	Rajasthan	Candu	200	-
Italy <sup>b/</sup>	E.N.E.L. - Latina	Latina	GCR	160	x
	E.N.E.L. - Garigliano	Garigliano	BWR	160	x
	FERMI-TRINOVER	Turin	PWR	256	x
	E.N.E.L. - Caorso	Caorso	BWR	920	x

State <sup>a/</sup>	Name of power reactor	Location	Type	Capacity MW(e)	In operation
Japan	Fugen	Tsuruga	ATR	165	-
	Fukushima-1	Okuma-Fukushima	BWR	460	x
	Fukushima-2	Okuma-Fukushima	BWR	784	x
	Fukushima-3	Okuma-Fukushima	BWR	784	x
	Fukushima-4	Okuma-Fukushima	BWR	784	-
	Fukushima-5	Fukushima	BWR	784	x
	Genkai-1	Kyushu	PWR	559	x
	Hamaoka-1	Hamaoka-cho	BWR	540	x
	Hamaoka-2	Hamaoka-cho	BWR	840	-
	Ikata-1	Nishiuwagun	PWR	538	x
	Mihama-1	Mihama-Fukai	PWR	340	x
	Mihama-2	Mihama-Fukai	PWR	500	x
	Mihama-3	Mihama-Fukai	PWR	826	-
	Ohi-1	Ohi-cho	PWR	1175	x
	Ohi-2	Ohi-cho	PWR	1175	x
	Shimane	Kashima-cho	BWR	460	x
	Takahama-1	Takahama	PWR	826	x
	Takahama-2	Takahama	PWR	826	x
	Tokai-1	Tokai-Mura	Magnox	154	x
	Tokai-2	Tsuruga City	BWR	1100	x
Tsuruga	Tsuruga	BWR	357	x	
Korea, Republic of <sup>b/</sup>	Kori-1	Kori	PWR	564	-
Mexico <sup>d/</sup>	Laguna Verde	Laguna Verde, Vera Cruz	BWR	650	-
Netherlands <sup>b/</sup>	GKN-Dodewaard	Dodewaard	BWR	54	x
	PZEM-Borssele	Borssele	PWR	468	x
Pakistan	KANUPP	Karachi	Candu	125	x
Spain	Almaraz-1	Prvince of Caceres	PWR	930	-
	Almaraz-2	Prvince of Caceres	PWR	930	-
	Asco-1	Province of Tarragona	PWR	930	-
	Asco-2	Province of Tarragona	PWR	930	-
	Cofrentes	Province of Valencia	BWR	975	-
	José Cabrera	Almonacid de Zorita	PWR	153	x
	Lemoniz-1	Province of Viscaya	PWR	930	-
	Lemoniz-2	Province of Viscaya	PWR	930	-
	Santa Maria de Garona	Province of Burgos	BWR	440	x
	Sweden <sup>b/</sup>	Barsebäck-1	Near Malmö	BWR	580
Barsebäck-2		Near Malmö	BWR	580	x
Forsmark-1		Near Uppsala	BWR	900	-
Forsmark-2		Near Uppsala	BWR	900	-
Oskarshamn-1		Oskarshamn	BWR	440	x
Oskarshamn-2		Oskarshamn	BWR	580	x
Ringhals-1		Near Göteborg	BWR	760	x
Ringhals-2		Near Göteborg	PWR	830	x
Ringhals-3		Near Göteborg	BWR	830	-
Switzerland	Mühleberg	Mühleberg	BWR	306	x
	Beznau I	Beznau	PWR	350	x
	Beznau II	Beznau	PWR	350	x

C. Conversion plants, fuel fabrication plants, enrichment plants and chemical reprocessing plants including pilot plants with an annual throughput or inventory exceeding one effective kilogram

State <sup>a/</sup>	Abbreviated name	Location	Type of plant
Argentina	Pilot Fuel Fabrication Plant	Constituyentes	Pilot fuel fabrication
Belgium <sup>b/</sup>	FBFC	Dessel	Bulk fuel fabrication
	Belgonucleaire-BN-MOX	Dessel	Mox bulk fuel fabrication
Canada <sup>b/</sup>	CRNL Fuel Fabrication Plant	Chalk River	Pilot fuel fabrication
	Canadian General Electric Fuel Fabrication Plant	Peterborough Ontario	Bulk fuel fabrication
	Canadian General Electric Pelletizing Plant	Toronto Ontario	Bulk fuel fabrication
	Westinghouse Fuel Fabrication Plant	Port Hope Ontario	Bulk fuel fabrication
	Eldorado Nuclear Ltd.	Port Hope Ontario	Bulk conversion
	Westinghouse Fuel Fabrication Plant	Varenes Quebec	Bulk fuel fabrication
China, Republic of	INER Fuel Fabrication Plant	Lung Ton	Bulk fuel fabrication
Czechoslovakia <sup>b/</sup>	Nuclear Fuel Institute	Prague	Pilot fuel fabrication
Denmark <sup>c/</sup>	Metallurgy Department Risø	Risø	Pilot fuel fabrication
Germany, Federal Republic of <sup>b/</sup>	ALKEM-Wolfgang	Hanau	Mox conversion and bulk fuel fabrication
	ALKEM-Karlstein	Karlstein	Mox fuel fabrication
	NUKEM-Wolfgang	Hanau	Bulk conversion and fuel fabrication
	RBW-1-Wolfgang	Hanau	Conversion and bulk fuel fabrication
	RBW-2-Karlstein	Karlstein	Bulk fuel fabrication
	KWU-Karlstein	Karlstein	Pilot fuel fabrication
	GWK-WAK-Leopoldshafen	Karlsruhe	Reprocessing plant
India	Nuclear Fuel Complex	Hyderabad	Enriched uranium fuel bulk conversion and fabrication
Italy <sup>b/</sup>	Fabnuc-Bosco Marengo	Alessandria	Bulk fuel fabrication
	COREN	Saluggia	Bulk fuel fabrication
	EUREX	Saluggia	Reprocessing plant
	IFEC	Saluggia	Pilot fuel fabrication
	ITREC-Trisaia	Rotondella	Pilot reprocessing plant
Japan	PNC Reprocessing Plant	Tokai Mura	Bulk fuel reprocessing
	NFI (Kumatori-1)	Kumatori Osaka	Bulk fuel fabrication
	SMM (Tokai-1)	Tokai Mura	Bulk fuel fabrication
	MAPI (Ohmiya-1)	Ohmiya	Bulk fuel fabrication
	JNF	Yoko Soka	Bulk fuel fabrication
	MNF	Tokai Mura	Bulk fuel fabrication
	PNC (Tokai-1)	Tokai	Bulk fuel fabrication
	MAPI (Ohmiya-2)	Ohmiya	Pilot fuel fabrication

State <sup>a/</sup>	Abbreviated name	Location	Type of plant
	NFI (Kumatori-2)	Kumatori Osaka	Pilot fuel fabrication
	SMM (Tokai-2)	Tokai Mura	Pilot fuel fabrication
	NFI (Tokayama-2)	Tokayama	Pilot fuel fabrication
	PNC (Tokai-2)	Tokai Mura	Pilot enrichment
Netherlands <sup>b/</sup>	URENCO-Almelo	Almelo	Enrichment plant
	Ultra-Centrifuge	Almelo	Pilot enrichment plant
Norway <sup>b/</sup>	Fuel Element Pilot Production Plant	Kjeller	Pilot fuel fabrication
Romania <sup>b/</sup>	Demfuel	Pitesti	Pilot fuel fabrication
Spain	Metallurgical Plant Juan Vigon Research Centre	Madrid	Pilot fuel fabrication
	Pilot Reprocessing Plant Juan Vigon Research Centre	Madrid	Pilot fuel reprocessing
Sweden <sup>b/</sup>	ASEA - ATOM	Västeras	Bulk fuel conversion and fabrication

D. Other accountability areas covering more than one effective kilogram of nuclear material

State <sup>a/</sup>	Abbreviated name	Location	Type
Australia <sup>b/</sup>	Research Laboratory	Lucas Heights	R&D establishment
Belgium <sup>b/</sup>	CEN-Labo-Mol	Mol	R&D facility
	BCMN-Geel	Geel	R&D facility
	IRE-Mol	Mol	R&D facility
	Overpelt-Olen	Olen	Separate storage facility
	Eurochemic-Mol	Mol	Separate storage facility
	BN-Mol	Mol	Separate storage facility
Canada <sup>b/</sup>	Chalk River Nuclear Laboratories	Chalk River	R&D establishment
Czechoslovakia <sup>b/</sup>	Research Laboratories	Rez	R&D establishment
Denmark <sup>c/</sup>	FAB, STO, Risø	Risø	Separate storage facility
German Democratic Republic <sup>b/</sup>	Miscellaneous locations combined in one material balance area	Various	Other locations
Germany, Federal Republic of <sup>b/</sup>	KFA-NEA-Jülich	Jülich	R&D facility
	GFK-LAB-Karlsruhe	Karlsruhe	R&D facility
	KFA-LAB-Jülich	Jülich	R&D facility
	KWU-Hotcell-Karlsruhe	Karlsruhe	R&D facility
	GFK-Hotcell-Karlsruhe	Karlsruhe	R&D facility
	TRANSURAN-Karlsruhe	Karlsruhe	R&D facility
	GFK-RA, CHEM, Karlsruhe	Karlsruhe	R&D facility
	KWU-LAB-Erlangen	Erlangen	R&D facility
	TRADE-Karlsruhe	Karlsruhe	Separate storage facility
	Braunkohle-Wesseling	Wesseling	Separate storage facility
	GFK	Karlsruhe	Sub-critical assembly
Hungary <sup>b/</sup>	Institute of Isotopes	Budapest	R&D facility
Italy <sup>b/</sup>	CNEN-LAB, TEC-Casaccia	Casaccia	R&D facility
	CNEN, LAB, PU, -Casaccia	Casaccia	R&D facility
	CCRM-Ispra	Ispra	Separate storage facility
	CCRM-ECO	Ispra	Separate storage facility
	AGIP Bosco-Marengo	Alessandria	Separate storage facility
Japan	JAERI	Tokai	R&D facility
	PNC	Oarai	R&D facility
	Electro-technical Lab.	Tanashi	Other locations
	Tokyo Univ, Tokai	Tokai-mura	Other locations
Netherlands	R. LABO-Petten	Petten	R&D facility
Poland <sup>b/</sup>	Institute of Nuclear Research	Świerk	R&D facility
	Miscellaneous locations combined in one material balance area	Various	Other locations
Sweden <sup>b/</sup>	Miscellaneous locations combined in one MBA	Various	Other locations
	Central Hot Laboratory	Studsvik	R&D establishment

State <sup>a/</sup>	Abbreviated name	Location	Type
UK	Windscale storage facility	Windscale	Separate storage facility
	Zebra storage facility	Winfrith	Separate storage facility
USA	Argonne National Laboratory	Argonne	Separate storage facility

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

b/ NPT safeguards agreement.

c/ Prior to the entry into force on 21 February 1977 of the safeguards agreement between the seven non-nuclear-weapon States of EURATOM, EURATOM and the Agency, NPT safeguards were applied in Denmark under the NPT agreement with Denmark which entered into force on 1 March 1972.

d/ Safeguards agreement in connection with the Treaty for the Prohibition of Nuclear Weapons in Latin America (Tlatelolco Treaty) and NPT.

## INFORMATION AND TECHNICAL SERVICES

### Scientific journals

222. The two scientific journals, Atomic Energy Review and Nuclear Fusion, continued to be published regularly. Sixty laboratories in 16 Member States contributed to these journals. In view of an increase in the number of manuscripts and printed pages, it was decided, as of 1978, to publish Nuclear Fusion on a monthly basis. In 26 review articles and surveys published in Atomic Energy Review in 1977, special emphasis was placed on areas of significance to the Agency's programmes.

### The International Nuclear Information System (INIS)

223. In 1977 the number of Member States participating in INIS increased to 52 (see map). In addition 13 international organizations contributed information. Over 69 000 references to nuclear information were processed by INIS, the largest number in its eight-year history. These bring the total size of the information file built up since INIS operations commenced to almost 350 000 items. Copies of almost 100 000 of these items are available from the INIS Clearinghouse in microfiche format.

224. During the year work began on the establishment of an experimental on-line facility by which Member States can consult INIS files on the Agency's computer from computer terminals installed in the countries concerned. The announcement of the experiment, early in 1977, met with a most encouraging response from Member States; 18 countries indicated their wish to participate.

225. The acquisition during the year of an advanced photocomposition machine has made it possible to convert input in many forms into high-quality printed output. The number of subscriptions to "INIS ATOMINDEX" increased during 1977, reaching a total of 1800, as compared to 1500 in the previous year.

226. The INIS training programme consisted of a four-week intensive training course in May/June 1977 for participants from developing countries. Five of the trainees were awarded IAEA fellowships. In addition, two specialized INIS seminars/workshops were organized in the United States of America and the Soviet Union in April and September, respectively. AGRIS participated in a number of these training activities.

227. In March, a technical committee of experts from Member States met in Vienna to make recommendations on the expansion of the scope of INIS to include information on the medical applications of ionizing radiations and radionuclides. Also, in 1977 a consultant was engaged by the Agency to develop a scheme and implementation plan for the indexing of records in the INIS data base that contain numerical data. The recommendations of both the technical committee and the consultant are expected to be incorporated into the INIS procedures during 1978/79.

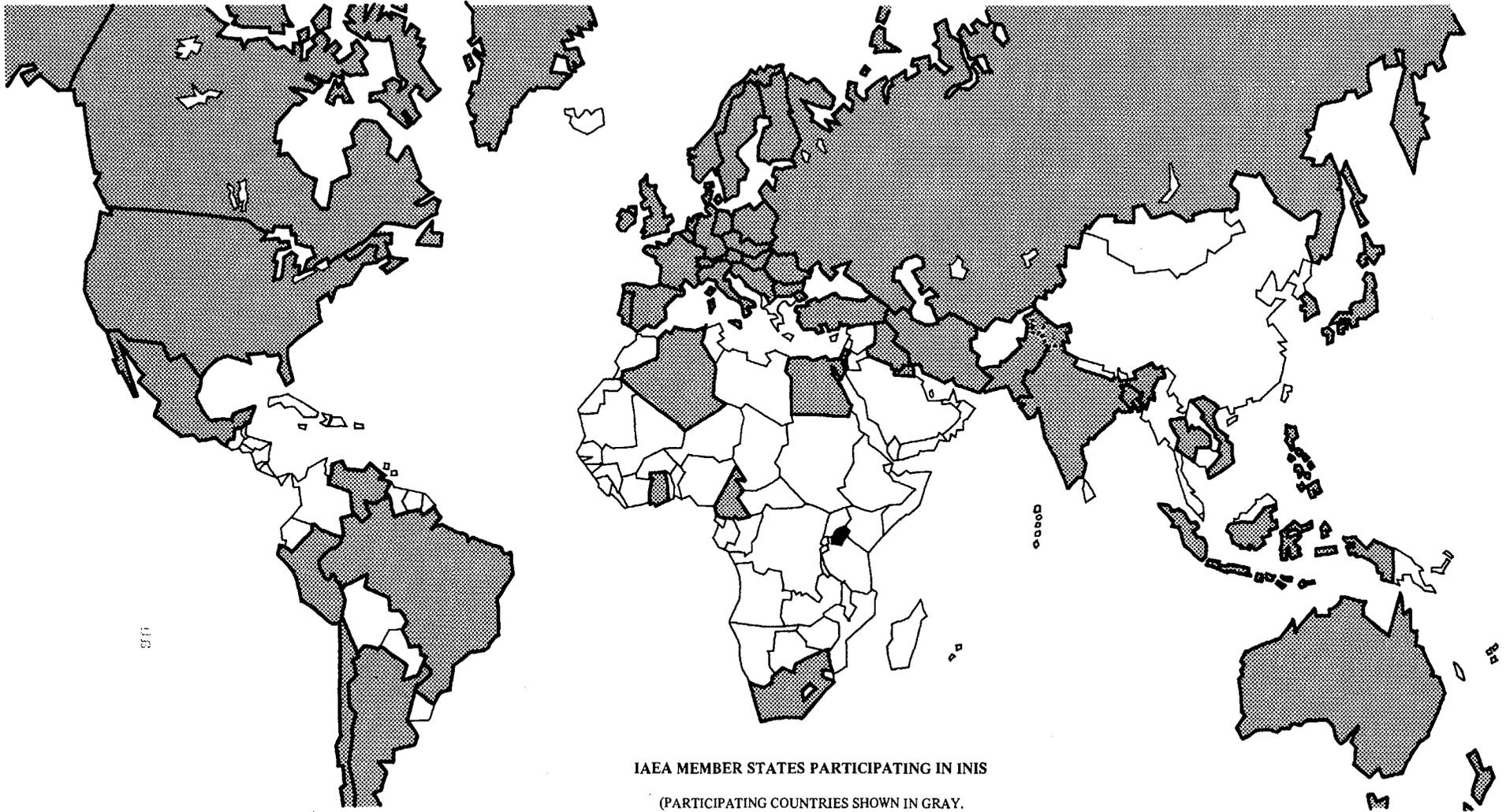
### Computer services

228. A new computer, an IBM 370/158, was installed in June 1977. This computer is more powerful than the previous IBM 370/145 and allows fast processing of safeguards data, supports the Agency's and UNIDO's computerized administrative and information systems, processes data for INIS, and is the central resource for development of access to data by means of teleprocessing equipment.

229. A data security study has been performed to ensure that safeguards data are adequately protected against unauthorized access. In response to the recommendations contained in the data security study the Agency took steps to (a) adopt MVS (Multiple Virtual System) as the only operating system on the computer; (b) install special security software; (c) introduce separate job entry and output stations for particularly sensitive information.

230. On-line data entry has been introduced for INIS and AGRIS, which means faster updating of their data bases. On-line information searches have also been introduced and are widely used.

231. Remote job entry terminals have been installed for safeguards nuclear data, UNIDO, and the Agency's computer, to allow remote entry of computer jobs, and the possibility of returning results on the terminal printer.



IAEA MEMBER STATES PARTICIPATING IN INIS  
(PARTICIPATING COUNTRIES SHOWN IN GRAY.  
NATIONAL BOUNDARIES DRAWN APPROXIMATELY ONLY)

## ADMINISTRATION

### Legal services

232. The Agency was responsible for arranging and assisting an international conference on the drafting of a Convention on the Physical Protection of Nuclear Material.

233. The Vienna Convention on Civil Liability for Nuclear Damage[6], adopted in Vienna on 21 May 1963, entered into force on 12 November 1977, in accordance with its Article XXIII, three months after the deposit of the instrument of ratification by Yugoslavia. The Convention is now in force for: Argentina, Bolivia, Cuba, Egypt, the Philippines, Trinidad and Tobago, the United Republic of Cameroon, and Yugoslavia. The Vienna Convention has also been signed by Colombia, Spain and the United Kingdom.

234. The Agency provided advice to Malaysia and Morocco on legal and regulatory matters connected with the licensing and liability aspects of nuclear installations.

### Meeting programme

235. Comparative information on the Agency's meeting programme for the years 1976 and 1977 is given in Table 11.

Table 11

Meetings convened by the Agency

Item	1976	1977
Conferences and symposia	12	11 <sup>a/</sup>
Participants	2292	3543
Countries taking part	72	72
Papers presented	679	849
Seminars	1	5
Participants	37	244
Countries taking part	10	34
Papers presented	20	106
Other meetings (technical committees, advisory groups, etc.)	204	227

<sup>a/</sup> Including Salzburg Conference.

### Permanent Headquarters

236. During the year, work continued on the completion of the Agency's Permanent Headquarters at the Donaupark. It is foreseen that the premises will be ready for occupancy during the second half of 1979.

[6] Reproduced in Legal Series No. 4, Revised 1976 Edition.

237. The Donaupark complex will be the site of the permanent headquarters of the IAEA and UNIDO, and will also house various United Nations units. The building complex will have approximately 125 000 square metres of net usable space. The services for the buildings will be mutually provided by the participating organizations. A memorandum of understanding outlining the organization of the common services was signed in Vienna in March 1977 by the Secretary-General of the United Nations and the executive heads of the IAEA and UNIDO.

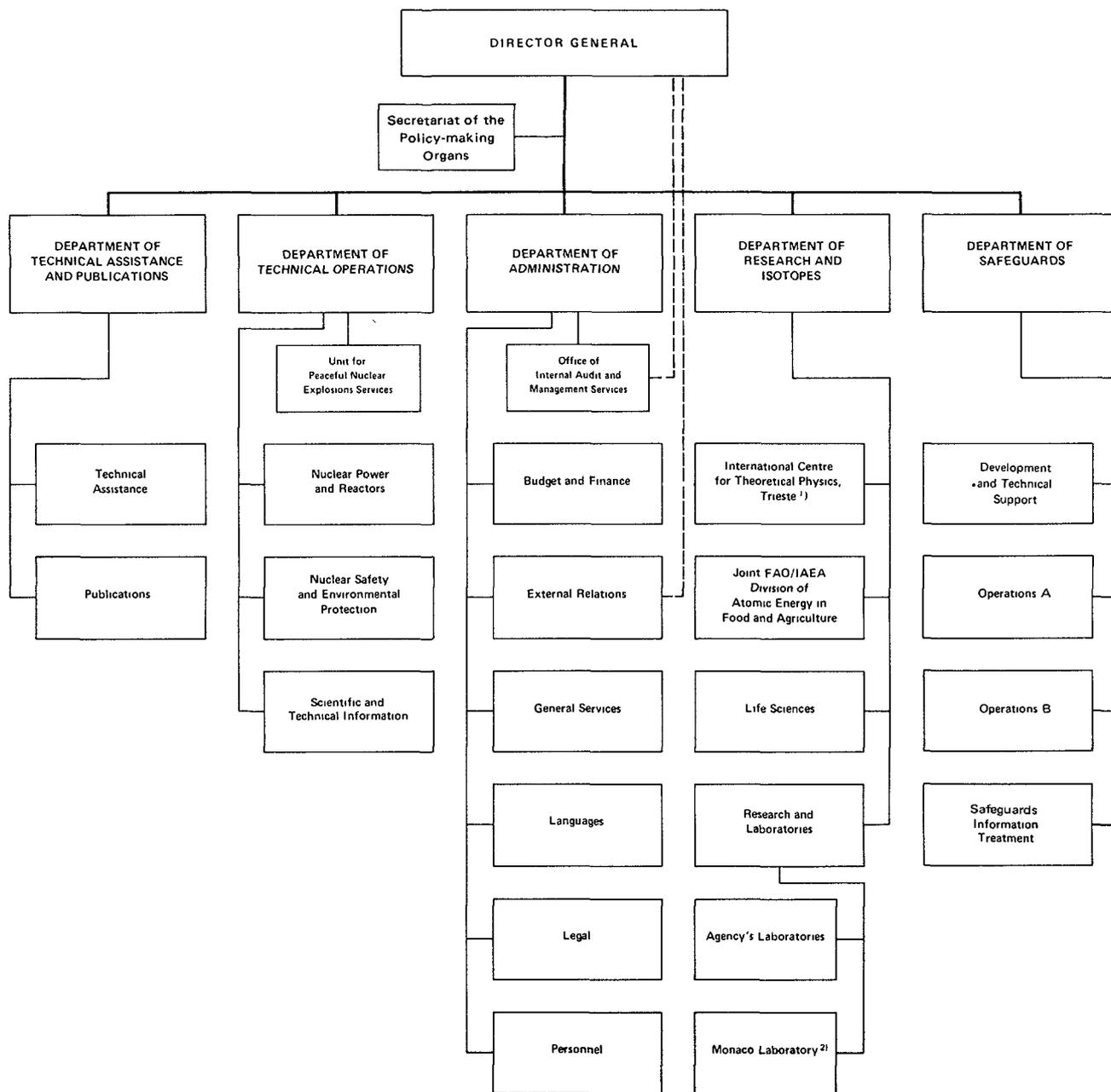
#### Personnel

238. During 1977, 183 staff members left the Agency and 262 were appointed. Among the new appointees, 89 staff members were in the Professional category, of which five were women.

239. On 31 December 1977, the Secretariat had 577 staff members in the Professional and higher categories, 733 in the General Service category and 275 in the Maintenance and Operatives Service category. The number of nationalities represented among that portion of the staff which is subject to geographical distribution was 64 on 31 December 1977, as compared to 58 the previous year.

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

# ORGANIZATIONAL CHART



1) Jointly operated by the Agency and UNESCO.  
 2) With the participation of UNESCO and UNEP.



