Technical co-operation for nuclear safety in developing countries

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When the International Atomic Energy Agency was established more than 25 years ago, it was mandated to accelerate and enlarge the contribution of atomic energy to peace, health, and prosperity throughout the world. This mandate carries with it a concomitant responsibility for the protection of man and his environment from any harmful effects of ionizing radiation.

From the very beginning, therefore, safety has been an integral part of the Agency's programme. This is reflected in the Agency's Technical Co-operation programme: statistics reveal that the steady increase in the volume of technical co-operation in the various nuclear fields has also brought with it an increase in work to strengthen nuclear safety in developing countries (Fig.1).

The Division of Nuclear Safety, like other technical divisions of the IAEA, is intimately involved in all aspects of technical co-operation: programming, project identification and formulation, implementation, output monitoring, and evaluation of results. Members of the staff of the Division of Nuclear Safety, in addition to their other duties, assume responsibility for numerous technical co-operation projects in their capacity as "technical officers":

- providing technical advice and support for projects;
- appraising new requests for assistance;
- evaluating fellowship applications technically;
- undertaking or participating in technical and programming missions;
- serving as lecturers at training courses;
- preparing and reviewing technical reports;
- reviewing fellowhip reports; and
- participating in evaluation activities.

In January 1984, technical officers of the Division of Nuclear Safety were involved in the execution of more than 150 technical co-operation projects. The actual involvement of Agency staff members in safety-related activities is even higher than outlined here, as a number of other technical co-operation projects such as those on radiation protection regulation, radiation dosimetry and radioactive waste management, also extend into the safety area.

The Agency's programme on technical co-operation for nuclear safety is, largely, responsive in character and the Agency's response is tailored to needs identified by developing countries. However, the Agency's assistance alone is not sufficient: technical co-operation can only be successful and is most effective when there is also a strong input from the counterpart body participating in a particular project. The commitment of national governments is fundamental to success. Technical co-operation is most fruitful if the Agency's assistance capabilities and the recipient country's co-operation capabilities match. Co-operation activities mostly take the form of single projects hosted by individual institutions within a single country; regional and inter-regional projects are also important.

Radiological safety

The objective of the technical co-operation programme on radiological safety is to enhance the level of safety in various operations involving the use of radioactive material and radiation sources in developing countries. Activities supported range from the establishment of national regulatory frameworks for radiation protection, and the implementation of means to ensure compliance with such regulations, to the strengthening of technical capabilities such as resources of radiation protection equipment. The Agency's inputs comprise mainly the provision of expert services and equipment, fellowships and, to a lesser extent, awards to enable scientific visits. These are supplemented by specific training courses on safety, and by support for the attendance of experts from developing countries at scientific meetings.

The following brief listing may serve as an illustration of needs recognized and the aims of single projects supported under the 1984 regular technical co-operation programme on radiological safety:

- Preparation of radiation protection regulations; development of appropriate radiation protection infrastructures, and establishment of inspectorates for radiation safety control (organizational and technical aspects).
- Establishment of radiation protection service units, in particular the provision of adequate personnel monitoring services for assessment of external and internal radiation exposure.

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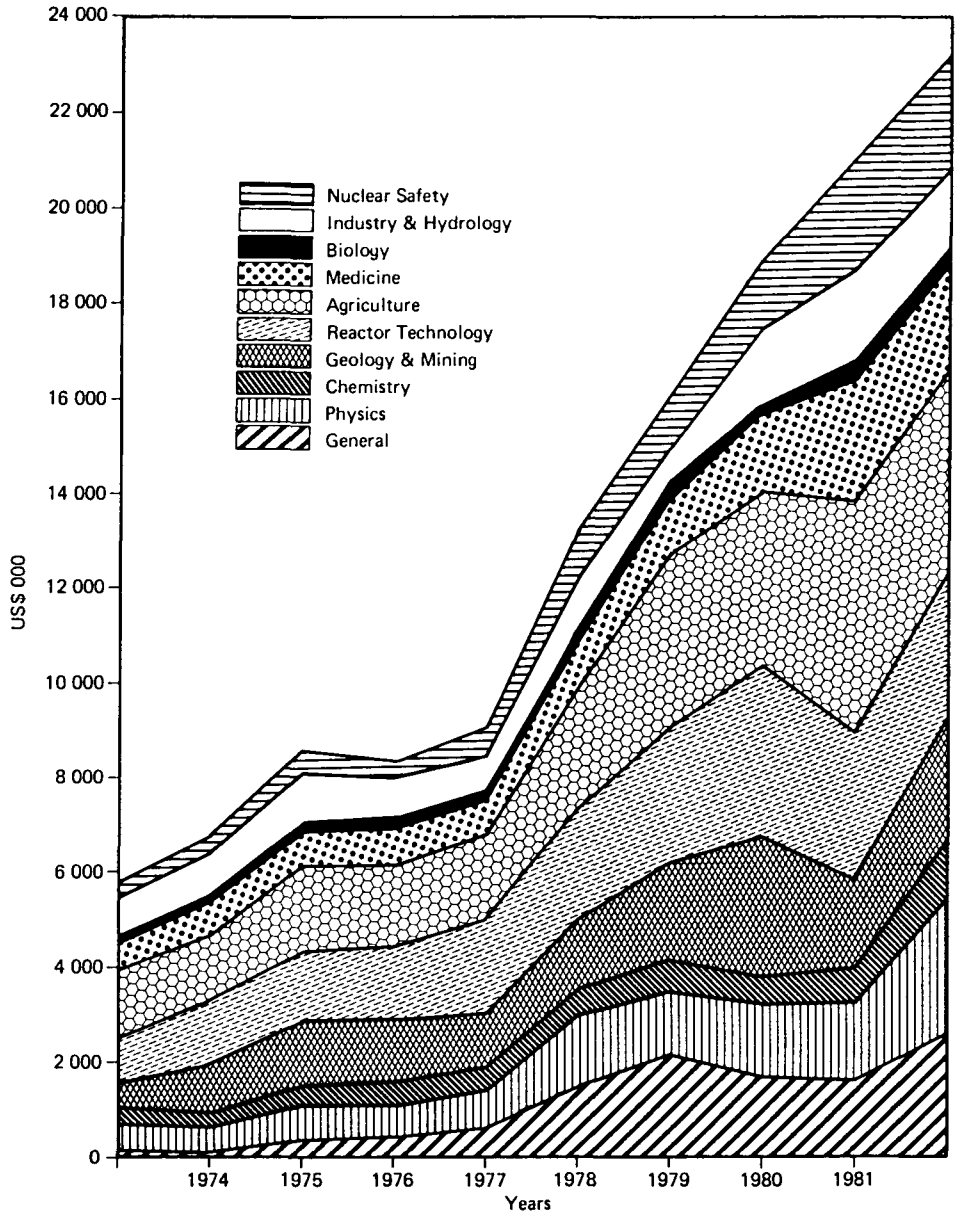

Figure 1.
IAEA Technical co-operation programme by field of activity: 1973–1982.

- Improvement of methods in occupational radiation protection; enhancement of the level of safety at installations such as nuclear research reactors and related facilities, and uranium mines and mills.
- Establishment and strengthening of environmental safety programmes; enhancement of analytical capability for determination of low-level radiation; pre-operational survey of environmental radioactivity.
- Review and improvement of emergency procedures; assessment of effectiveness of off-site and on-site emergency plans; provision of equipment for accident monitoring and assessment; strengthening human radiotoxicology capability.

Single projects

Most technical co-operation takes the form of single projects that are limited in scope and are generally designed to be implemented within one calendar year.

Typical project titles are: radiological safety inspection; radiation protection in uranium mining and milling, research reactors, and nuclear power plants; radiation protection services, personnel monitoring services, thermoluminescence dosimetry, neutron dosimetry, and internal contamination monitoring; environmental radioactivity monitoring and low-level radioactivity measurements; nuclear institute development, nuclear emergency response planning, radiological accident centre, and human radiotoxicology.

Regional and inter-regional projects

Particular attention is being given to radiation protection as a part of the Agency's activities in relation to the Andean countries' sub-regional co-operative programme (described in the article "Towards a Regional Co-ordinated Programme in Latin America"). It is intended that projects covering the areas of radiation protection regulation, radiation safety inspection, and technical aspects of radiation protection should be implemented. It is expected that some of these projects will become operational during the course of this year.

In 1982, the Agency, in a joint undertaking with the International Labour Organization (ILO), the Nuclear Energy Agency (NEA) of the OECD, and the World Health Organization (WHO), issued revised Basic Safety Standards for Radiation Protection (BSS). An examination of the programme by external advisors stressed the need for increased efforts in radiation protection education and training. The BSS, which incorporate new recommendations of the International Commission on Radiological Protection (ICRP), are intended to improve radiation safety for both workers and the general public.

In the light of the growing interest in radiation protection shown by developing Member States, an inter-regional project was designed to assist counterpart organizations in adapting the BSS to local conditions, and to promote training in various aspects of radiation protection. Three man-years of expert services spread over a two-year period were earmarked for this project. Its primary objective is to accelerate efforts aimed at assisting developing Member States effectively in the practical implementation of the new BSS, and to strengthen their radiation protection capabilities.

Direct co-operation

In most technical co-operation projects, the Agency's rôle is very much that of an agent, assisting in making arrangements for technical co-operation within the financial resources allocated by Member States. However, to the extent possible, the Agency is also more directly involved in technical co-operation activities. When needed, staff members of the Agency serve in advisory missions; statistics reveal that assignments carried out by staff of the Division of Nuclear Safety in the past two years represented roughly 10% of the total time spent by Agency staff on technical assistance missions. In 1981 the Agency also started to provide directly, on a limited scale, personnel dosimeters to radiation workers in five Member States (Ethiopia, Mali, Nigeria, Senegal, and Sierra Leone), where Agency-assisted operations had been undertaken but local personnel monitoring services were not initially available. Particular efforts were made to establish personnel monitoring services based on thermoluminescence dosimetry in Ethiopia, Ghana, Kenya, Sudan, and Tunisia. In 1983, Fellows from six countries received a total of 25 man-months of training in radiation protection.

Problems encountered

Medical uses of ionizing radiation came first in most countries, and supervision of radiation safety often rested with the medical authorities. However, there is now an evident shift of emphasis from mainly medical applications to non-medical uses of radiation. A polarization of radiation protection responsibilities between the medical and non-medical areas often accompanies this process, as tasks related to non-medical applications often extend beyond the technical competence of medical bodies. Centralization of radiation control in one authority is often inhibited.

Secondly, technical co-operation is becoming more and more complex, and the tasks of experts and missions, and equipment needs, more specific. This is occurring at a time when the spectrum of different types of instruments offered on the market is expanding. The process of selection of appropriate experts and items of equipment is becoming more difficult, and more and more attention to detail is required.

In addition, it must be noted that the simple transfer of technologies is not possible. Elaboration of new techniques and knowledge is often necessary: for example radiation protection instruments that operate reliably under moderate climatic conditions can fail in tropical countries; very limited information is available on the behaviour of radionuclides in specific tropical ecosystems, and the information available in developed countries cannot simply be extrapolated for application in other geographical regions.

Nuclear safety

In the years since the Three Mile Island accident in 1979, a silent but significant revolution in the nuclear safety field has occurred. Lessons learned from the analysis of the TMI accident have been applied in the design of new systems, and in the modification and updating of old ones. More intensive care is being given to the man-machine interface and to human factors in the operation of plants, with greater emphasis on and a more realistic approach to emergency planning and preparedness. The powerful tool of probabilistic risk assessment (PRA) is being used more widely than before, and is expanding to areas such as site analysis and the analysis of structural behaviour under external loads.

Developing countries with nuclear power programmes, and those which have such programmes in their future planning (Table 1), have to absorb quickly all these concepts and tools. To begin a nuclear power programme now means having to accept all the new safety philosophy without having had the benefit of experiencing its slow development with time.

The introduction of nuclear power technology and the construction of a nuclear power plant constitute a major step-change in a country's level of technological development, especially in some cases. One of the main functions

Table 1. Reactor units in developing countries

Country	Operating in 1983	Planned for operation in 1986
Argentina	2	2
Bulgaria	4	5
Brazil	1	1
Czechoslovakia	3	8
Cuba	–	–
Hungary	1	4
India	4	6
Korea, Rep. of	3	6
Mexico	–	2
Philippines	–	1
Pakistan	1	1
Poland	–	–
Romania	–	–
Turkey	–	–
Yugoslavia	1	1
Total	20	37

of the IAEA technical assistance programme is to ensure that this change in level of technological development occurs as smoothly and as efficiently as possible. This can be achieved through the work of missions, combined with the assignment of experts, training courses, and other forms of direct and indirect assistance. (See Tables 2 and 3)

The first impact of a nuclear programme upon a country's technical and regulatory structure is the selection and qualification of the site for the first unit, and the definition of the design basis. At this stage, it is important to ensure an efficient interaction between local experts, who have the site data and are familiar with the local situation, and external experts who know the techniques best suited to studying the site data and evaluating the potential impacts of natural phenomena. Seismic data, for example, together with geological and tectonic information, may be available for a given period. The task of the experts would be to decide whether the available data are sufficient, or whether other investigations are needed. The data and the geo-structural situation must then be correlated. After this the evaluation of the seismic parameters can begin. Parallel situations may occur in the hydrological evaluation of design basis floods; and in meteorology, in the evaluation of extreme events. Another important problem at this stage is a careful evaluation of the political, economic, and social aspects of site selection. The Agency can and does give considerable assistance at this stage, sending siting advisory missions both to solve specific technical problems and to advise on siting aspects in general.

A second and also very important aspect of a nuclear project is the evaluation of the safety of the nuclear power plant itself. The country's regulatory agency must declare that the level of safety to be achieved is acceptable. This means that, to be able to express their own judgement, the local experts must acquire a full understanding of the complicated systems of the plant. This is difficult to achieve, given the present "revolution" in nuclear safety, with standards being revised and consideration being given to the need to guard against very severe accidents. Expressing a judgement on plant safety is a highly complex task, because it requires not only understanding of the plant itself, but the availability of methodologies for re-evaluation of the system performance in fault conditions, and for the evaluation of accident consequences. At this stage, also, the Agency can lend assistance through advisory missions, the assignment of experts, and training of experts in safety analysis review within the national regulatory body.

Construction, commissioning, and operation of the power plant follow the preparatory work. At these stages inspection and quality assurance play an important rôle, and the Agency gives substantial assistance in training local people in these tasks. The most critical issues are those connected with safety during operation, because during construction and commissioning there is usually quite a large contribution from the vendor and suppliers. When the operational phase begins the plant owner and operator is left with only some initial assistance; plant operation is a local effort and maximum care must be exercised. Plant operators are trained by the suppliers but, prior to final specialized high-level training, preparatory training can be done with Agency assistance. Training must also be given to personnel within the regulatory body, which has to establish a system of examinations and tests for the licensing of plant operators. The whole field of plant operation is one in which the assistance of the Agency can be extremely helpful. In particular, it has been realized that the exchange of information on abnormal events and incidents on nuclear power plants is very important to assurance of operational safety. As a result, the Agency has set up an Incident Reporting System (IRS), to collect information from Member States which have active nuclear programmes, and to make it available to plant operators and to regulatory bodies within the nuclear community.

In the area of operational safety, the Agency has also begun a programme of Operational Safety Review Team (OSART) missions comprising experts who have extensive experience in plant operation. OSART missions are sent on request to review the status of nuclear power plants and to assess their ability to operate safely. Two OSART missions have already been performed, and many more are expected to follow: Member States have shown considerable interest in them.

These activities in the operational safety field reflect another important development which is taking place: a shift in safety research, from design for safety, to safety in operation. Apart from the previously mentioned activities, the Agency is assisting Member States in this

Table 2. Nuclear power safety assistance to Member States (since 1975)*

Missions**			
Siting	Safety report review	Regulatory body advisory	Nuclear legislation advisory
Argentina	Brazil	Brazil	Algeria
Chile	Iran	Chile	Brazil
Egypt	Korea, Rep. of	Egypt	Egypt
Indonesia	Philippines	Greece	Kuwait
Kuwait	Yugoslavia	Korea, Rep. of	Libyan Arab Jamahiriya
Libyan Arab Jamahiriya		Mexico	Malaysia
Malaysia		Pakistan	Morocco
Morocco		Philippines	Yugoslavia
Pakistan		Portugal	
Peru		Spain	
Philippines		Syria	
Turkey		Turkey	
Venezuela			
Yugoslavia			

Expert assistance		
Long term***	Short term	
Brazil	Argentina	Korea, Rep. of
Korea, Rep. of	Brazil	Mexico
Mexico	Bulgaria	Philippines
Philippines	Chile	Portugal
Yugoslavia	Greece	Romania
	Iran	Turkey
	Israel	Yugoslavia

* Funded by various departments of the IAEA (does not include fellowships, equipment or scientific visits).
** 1 to 3 weeks duration, 1 to 5 experts.
*** One year residence, or longer.

Table 3. IAEA Inter-regional safety-related training courses (1978–1983)

Course*	Location	Starting date	Duration (weeks)
Safety Analysis Review	Argonne (USA)	Aug. 1978	8
Quality Assurance	Argonne (USA)	Oct. 1978	5
Siting for Nuclear Power Plants	Argonne (USA)	Sep. 1979	9
Quality Assurance	Madrid (Spain)**	Oct. 1979	6
Safety and Reliability in Operation	Argonne (USA)	Nov. 1979	6
Safety Analysis Review	Karlsruhe (FRG)	Nov. 1979	4
Environmental Impact Assessment of Nuclear Power Plants	Argonne (USA)	Mar. 1980	6
Inspection of Nuclear Power Plant Construction	Argonne (USA)	Jun. 1980	9
Safety Analysis	Karlsruhe (FRG)	Sep. 1980	6
Regulation of Nuclear Power Plants	Argonne (USA)	Sep. 1980	9
Quality Assurance	Karlsruhe (FRG)	Oct. 1980	6
Safety Analysis Review	Argonne (USA)	Mar. 1981	8
Radiation Protection and Nuclear Safety	Buenos Aires (Argentina)**	Jun. 1981	7
Operational Safety	Karlsruhe (FRG)	Sep. 1981	6
Siting	Argonne (USA)	Sep. 1981	7
Radiological Emergencies Planning	Argonne (USA)	Feb. 1982	3
Seismic Considerations in Siting	Argonne (USA)	Feb. 1982	5
Risk Prevention	Saclay (France)***	May 1982	4
Siting	Saclay (France)***	Oct. 1982	4
Quality Assurance	Saclay (France)***	Apr. 1983	5
Probabilistic Risk Assessment	Argonne (USA)	Sep. 1983	4

* About 30 participants per course.
** Conducted in Spanish.
*** Conducted in French.

field with expert assignments, meetings, seminars, training courses, and assistance in the use of computer codes.

In the field of nuclear emergency planning and preparedness, the Agency has maintained its own Radiation Emergency Assistance Plan and Programme since 1959. The Agency will arrange to provide assistance at the request of any Member State in which an accident involving exposure to ionizing radiation has occurred. These arrangements are being extended into a more comprehensive Nuclear Accident Assistance Plan, to enable the Agency to channel requests for, and offers of, assistance to a Member State in the event of a serious nuclear accident. However, it is recognized that requests for external assistance could probably not be met within the first few days of the occurrence of an accident; and it is therefore important that countries ensure, to as great an extent as possible, that they and their operators have their own capability to respond during this early post-accident phase. Upon request by a Member State, the Agency is prepared to assist in the development and improvement of emergency plans and preparedness arrangements, to advise on the adequacy of existing arrangements, and to provide assistance in testing these plans through the observation and evaluation of emergency preparedness exercises. All of these activities are supplemented by the development of technical guidance and the implementation of training programmes; for example, the Agency sponsors International Training Courses on "Planning, Preparedness and Response to Radiological Emergencies", presented by international experts and held at the Argonne National Laboratory, USA, which aim at giving participants from developing countries specialist training in various topical areas of emergency planning and preparedness.

Conclusion

The IAEA has attached great importance to stimulating co-operation between its Member States in the field of nuclear safety, practically from its inception more than 25 years ago. It has always been a good forum for the exchange of technical information in the international nuclear community, and has acted as a catalyst for interaction between countries of different technical and industrial backgrounds.

The results of the Agency's activities are clearly visible: a more uniform level of technical awareness of nuclear safety problems, a general effort to achieve a higher safety level, and an increasing number of personnel well trained in the various areas of nuclear safety. There are sure signs that developing countries are absorbing the new technologies well and efficiently: one indicator is the increasing number of requests for missions to advise on very specialized problems, and a correspondingly lesser need for missions and assignments to deal with more general problems.

The value of the Agency's programme of technical co-operation for nuclear safety in developing countries has increased steadily over the past decade and is, in 1984, more than US$ 2.3 million. The regular programme budget of the Division of Nuclear Safety for 1984 amounts to about US$ 5 million. Bearing in mind that all activities carried out under the Division's regular programme are aimed at enhancing safety, particularly in developing countries, this means that a total of US$ 7.3 million is devoted to this objective. This effort should, undoubtedly, have a significant impact in assuring nuclear safety.