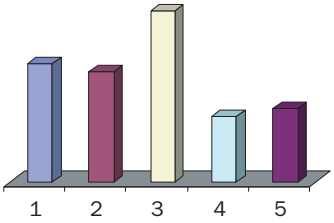
NUCLEAR SAFETY

PROGRAMME OBJECTIVE

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

Regular budget expenditure:$5 217 968

Extrabudgetary programme expenditure (not included in chart): $1 811 632



1. Nuclear Power Plant Safety Assessment: $1 143 373
2. Design and Engineering Safety: $1 077 237
3. Operational Safety: $1 660 428
4. Research Reactor Safety: $631 663
5. Regulatory Activities Related to Nuclear Safety: $705 267

OVERVIEW

Internationally accepted safety standards are an increasingly important element of the global nuclear safety culture, as they are adopted and applied or referred to more widely. Efforts to update the Agency's nuclear safety standards are now producing tangible results, with the publication in 2000 of Safety Requirements on the design and operation of nuclear power plants (as well as Safety Requirements on legal and governmental infrastructure for safety published in the general safety area), and three supporting Safety Guides.

The Agency provides safety services at the request of Member States as a means of facilitating the application of its safety standards and promoting good international safety practices. The services cover the areas addressed by the safety standards — the siting, design and operation of nuclear power plants, the safety of research reactors and the regulatory aspects of safety — and continue to be updated and tailored to meet Member State needs. The continuing, and in many cases increasing, demand for these services shows that Member States consider them to be beneficial to safety.

The results of Agency reviews demonstrate a general improvement in the safety of nuclear power plants and implementation of corrective safety measures, and progress in enhancing the effectiveness and technical capabilities of regulatory bodies. The number of significant events reported by nuclear power plants and regulators has steadily decreased over the last eight years, and there is a general move by utility and regulatory management towards promoting improvements in safety culture. Overall, there is evidence of a continuing general improvement in the operational safety of nuclear power plants throughout the world. However, a changing environment of increased competition from deregulation of electricity markets, social/political decision making for early plant closures and economic realignment of many countries could threaten this positive trend.

The safety of research reactors continues to cause concern. The Agency has responded to this concern with an expanded range of activities, and continues to explore options to strengthen international safety arrangements for such reactors.

NUCLEAR POWER PLANT SAFETY ASSESSMENT

Technical documents were prepared to assist in the implementation of the Agency's guidelines on accident analysis of nuclear power plants and on accident management programmes. These documents cover computer code analysis of in-vessel phenomena during severe accidents, incorporation of advanced accident analysis methodology into Safety Analysis Reports (SARs), applicability of computer codes for analysis of fuel safety criteria and training of accident management staff. In a related development, the Agency launched a new service in 2000, the Review of Accident Management Programmes (RAMP). A pilot review mission has been scheduled for 2001 at the Krško nuclear power plant in Slovenia.

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The first phase of an extrabudgetary project on accident analysis for the Kursk-1 nuclear power plant in the Russian Federation (an RBMK-1000 unit) ended in 2000. The analysis methodology, using both foreign and Russian computer codes, was validated through a detailed assessment of the models used. The results will help plants in achieving independent accident analysis capabilities, and are applicable to any first generation RBMK power reactor. The second phase of the project will be the development of a training programme.

In 1999, the Secretariat was requested by the Advisory Commission on Safety Standards (now the Commission on Safety Standards (CSS)) to prepare a report on the current status of national regulations and safety related issues for nuclear fuel cycle facilities other than nuclear power plants and research reactors. The report, completed in 2000, concluded that more than 250 facilities of different type and capacity are in operation worldwide, and some 60 facilities are either in the design stage or under construction. Although some of the safety hazards at reactor and non-reactor facilities are similar, there are some specific safety concerns at non-reactor fuel cycle facilities that must be given consideration in their design and operation, such as criticality, chemical toxicity, fire and explosion hazards. At the request of the CSS, the Secretariat prepared a proposal for an integrated set of safety standards to address the safety of non-reactor nuclear fuel cycle facilities. On the basis of this proposal, the CSS asked the Secretariat to proceed with the development of these standards in 2001–2003.

In addition to deterministic safety approaches, operators are making greater use — as are regulators — of probabilistic safety assessment (PSA) results in safety related decisions. A document prepared to compile the status of PSA applications in Member States and experience in its use demonstrates that in the design area the most use of PSA is made in identifying and prioritizing safety upgrades. However, PSAs are also performed to support new designs in identifying plant vulnerabilities and important intersystem dependencies. PSAs now generally form part of the SAR of a new plant or of a Periodic Safety Review of an existing plant.

In the operational safety area, PSAs are used to optimize technical specifications and maintenance schedules, control the plant configuration, and analyse the safety significance of incidents. Increasing use is also being made of PSAs by regulatory bodies. The Agency's activities in this area are therefore concentrated on promoting the quality and consistency of PSAs as a prerequisite for their application in decision making. Working groups were set up to compare PSA results from similar types of nuclear power plant and for pooling reliability data of plant components for use in PSAs. The Agency prepared guidance on carrying out PSAs for low power and shutdown conditions and on regulatory review of Level 2 PSAs.

Six International PSA Review Team missions were carried out to review PSAs and to provide guidance on the use of PSA results (see the Annex, Table A3). Though the results of these reviews are dependent on the individual studies, in general the weak areas relate to the estimation of frequencies for initiating events, the definition of system success criteria for loss of coolant events, and the identification and modelling of human errors and common cause failures. Often weaknesses have been identified in the quality assurance process for the PSA and the preparation of the supporting documentation.

A technical document on operational safety performance indicators for nuclear power plants, published in 2000, summarized the results of the Agency's work over recent years. The key operational safety attributes — the factors that most strongly determine whether a plant operates safely — were identified. For each of these attributes, measurable indicators were established at the overall, strategic and specific levels. The proposed framework was tested by means of pilot studies at four plants, with each plant adapting the general framework to reflect plant specific considerations. The Agency and the OECD/NEA also jointly organized a specialists' meeting on the subject. Both the report and the meeting indicated that additional work is needed in a number of areas. Some of these are being addressed through a CRP on methodological topics and data collection and analysis, and the feasibility of an international system of safety performance indicators will be discussed in a session of the international conference on topical issues in nuclear safety that the Agency is hosting in September 2001.

An extrabudgetary programme on the safety of nuclear installations in South East Asia, the Pacific and Far East countries is strengthening regulatory bodies and the safety of nuclear power plants and research reactors in China, Indonesia, Malaysia, the Philippines, Thailand and Viet Nam. Some of the measures taken include the establishment of licensing processes and systems of inspection and enforcement for research reactors. Following guidance and training provided to Indonesia's regulatory body, a system for the qualification of inspectors is being prepared. Several regional and national training events were organized, and the participants — regulators and operators of nuclear power plants and research reactors — indicated that they found these events very beneficial in enhancing nuclear safety knowledge and technical competence.

The Agency began work in a number of countries to improve the scope and technical quality of SARs for research reactors. China was assisted in reviewing the SAR for the WWER-1000 nuclear power plant being built at Tian-

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wan, particularly in the areas of PSA, component integrity and conceptual design of the instrumentation and control systems, and in initiating a periodic safety review of the Qinshan-1 nuclear power plant.

Based on the Country Nuclear Safety Profiles that were developed in recent years and feedback from assistance missions, Nuclear Safety Action Plans were developed jointly by the Agency and the countries receiving nuclear safety support through the technical co-operation programme. These plans indicate priorities for establishing and maintaining a nuclear safety infrastructure that meets the requirements of the Agency's safety standards.

DESIGN AND ENGINEERING SAFETY

Revised Safety Requirements for the design of nuclear power plants were published in 2000. These specify internationally agreed design requirements for structures, systems and components important to safety that must be met for the safe operation of a nuclear power

plant, and for preventing or mitigating the consequences of events that could jeopardize safety. They also specify requirements for a comprehensive deterministic and probabilistic safety assessment of operating nuclear power plants and take into account the most recent developments in safety approaches. They supersede the 1988 *Code on the Safety of Nuclear Power Plants: Design*.

The first of a series of supporting Safety Guides was also published in 2000 on software for computer based systems important to safety. Two other Safety Guides, on instrumentation and control systems important to safety and on safety assessment and verification, have been approved for publication, and nine other revised Safety Guides on design safety are being prepared.

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The Agency published guidelines for the conduct of software safety review services. This is the fourth of the five areas of Engineering Safety Review Services for which guidelines have been published: guidelines for ageing management assessment teams, design safety review services and fire safety review services have already been published, and those for seismic safety review services will be published shortly.

A design safety review carried out by the Agency of the South African Pebble Bed Modular Reactor (PBMR) resulted in several key recommendations to improve the safety of the design and to make the demonstration of safety more complete, but did not identify any fundamental flaws in the safety area that would preclude a successful project. To overcome the lack of well established safety standards for this type of reactor, the Agency initiated an in-depth investigation of all safety aspects of modular high temperature gas cooled reactors and their implications for current safety standards. A team also reviewed the safety of, and regulatory requirements and guidance for, the Korean Next Generation Reactor (KNGR) design. The impact of Agency safety reviews of new designs has been very significant both to the States developing them and to the international community. The acceptance of innovative designs and design standards internationally hinges on the effective solution of design safety issues and Agency reviews provide a technical and unbiased basis for this assessment. The experience gained from these reviews will allow the Agency to be a focal point for the development of safety approaches for reactors of evolving or innovative design.

Through its technical co-operation programme, the Agency organized a review mission to units 1 and 2 of the Bohunice nuclear power plant in Slovakia, which are of first generation WWER-440/230 design. After reviewing documentation and conducting plant walkdowns, the reviewers concluded that a comprehensive and well justified safety upgrading programme had been developed and was being implemented. The programme defines a new safety case that satisfies national requirements and, in some cases, goes beyond the Agency's recommendations for the safety upgrading of reactors of this vintage. Another mission reviewed the modernization programme for units 5 and 6 of the Kozloduy nuclear power plant in Bulgaria. Both of these reviews demonstrated the significant progress in the safety of WWER nuclear power plants over the past decade.

Over the past five years, the Agency has sent about a dozen missions to the Islamic Republic of Iran to address various aspects of the safety of the Bushehr nuclear power plant. The design of this plant is unique: the civil engineering structures from a partially built PWR plant are being used to house a WWER-1000 reactor. The structures have also suffered war damage and been repaired, which makes the project even more challenging. In 2000, the Agency carried out a safety review of selected chapters of the Preliminary

Safety Analysis Report (PSAR) of unit 1 to assess the safety and provide comments and recommendations to improve the compliance of the design with its safety standards. A separate mission visited the Iranian Safety Authority to assist it in its review of the PSAR.

Intergranular stress corrosion cracking in stainless steel pipes is a recognized safety issue for water cooled reactors. An extrabudgetary programme on the mitigation of such cracking in the austenitic stainless steel piping of RBMK reactors aims to assist countries operating such reactors in establishing effective mitigation programmes, through technology transfer, training and guidance. Among the first activities under this programme, were two training courses on risk based inspection and on advanced ultrasonic testing for the detection, characterization and repair of cracking. In addition, a comprehensive information package developed in the USA on repair and mitigation techniques was given to the countries operating RBMK reactors.

OPERATIONAL SAFETY

A publication containing revised Safety Requirements for the operation of nuclear power plants was issued in 2000. It specifies internationally agreed requirements that, in the light of experience and the present state of technology, must be satisfied to ensure the safe operation of nuclear power plants. This publication supersedes the 1988 *Code on the Safety of Nuclear Power Plants: Operation.* The first two of the series of supporting Safety Guides were also published in 2000 on fire safety in operation and on operational limits and conditions and operating procedures. Two other Safety Guides, on plant modifications and on the operating organization, have been approved for publication, and seven other new or revised Safety Guides on operational safety are being prepared.

The process involving Operational Safety Review Team (OSART) missions now typically includes a self-assessment seminar well in advance of the mission, which enables the operator to begin the improvement process up to two years before the evaluation mission. Seven such seminars have been carried out to date. For most plants the improvement in operational and management standards over the period between the self-assessment seminar and the OSART follow-up mission is visible and demonstrable (see the Annex, Table A4).

Some Member States, such as France, Germany, India and the United Kingdom, carry out their own internal reviews of plant operational performance. At the invitation of France, the Agency attended an internal review at the Dampierre nuclear power plant to monitor and comment on the French process and test the guidelines developed by the Agency for the external assessment of national review processes. The French process was found to be both comprehensive and effective. Based on the lessons learned, the Agency's guidelines will be completed in early 2001 and a service offered to Member States for effectiveness assessments of national review processes.

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The management of operational safety and safety culture needs a comprehensive and balanced set of assessment tools and performance indicators that can be used by both operators and regulators. The Agency held three meetings in 2000 with those experienced in the successful application of safety culture assessment processes and tools in order to exchange experience and to publish successful practices. In light of the potential distraction of management from safety as a result of the competitive, financial and political pressures facing the industry, many utilities and regulators are now adopting a more comprehensive

set of indicators such as those developed by the Agency over the last three years and published in 2000.

Operating experience has been used successfully over many years in improving operational performance. The Agency has continued to develop its new comprehensive method for co-operation with Member States in assessing the effectiveness of and enhancing a nuclear power plant's entire operating experience and corrective action programme. Guidelines for a new service — the Peer Review of Operating Safety Performance Experience (PROSPER) — were developed in 2000, and a pilot mission carried out in the United Kingdom. Seven introductory seminars and workshops in five Member States prompted requests for further missions (see the Annex, Table A5).

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Three visits were made to the Chashma nuclear power plant in Pakistan to assist in enhancing the competence of plant managers in safely operating the plant. In addition, a joint Agency–Pakistani advisory committee was established to oversee the effectiveness of the management of plant operation. The Chashma unit has now been started up and taken over by the Pakistani operators, and the Agency is continuing co-operation.

As part of its increased collaboration with WANO, the Agency made presentations in both Ukraine and the Russian Federation to senior utility, plant and regulatory management. The presentations focused on the capabilities of the Agency for co-operation in such areas as self-assessment, operating experience, management of safety and safety culture. The Russian Federation subsequently requested Agency assistance in developing a utility wide self-assessment programme based on Agency standards. It has also requested that the Agency lead a seminar on self-assessment at the Kalinin nuclear power plant.

RESEARCH REACTOR SAFETY

In a letter to the Agency's Director General in April 2000, the Chairman of the International Nuclear Safety Advisory Group (INSAG) summarized "three major safety issues" concerning research reactors: the increasing age of operating research reactors; the large number of these reactors that are shut down but not decommissioned; and the number of research reactors not under adequate regulatory control. INSAG also suggested investigating the possibility of developing a legal instrument to cover the safety of these reactors. The Agency has taken steps to strengthen its research reactor safety activities in response to these concerns. For example, the review services now place higher priority on assessing and helping to improve regulatory effectiveness, and on operational safety aspects such as the management of safety and safety culture.

The Agency has a particular responsibility for the safety of research reactors under Project and Supply Agreements with Member States. General Conference resolution GC(44)/RES/14 requested the Secretariat to continue to explore options to strengthen international arrangements for research reactor safety, taking account of input from INSAG and others, and to continue to monitor closely those reactors subject to such agreements. Accordingly, eight safety review missions visited research reactors under agreement during 2000. Some reactors have specific safety problems requiring urgent solutions, and the Agency has taken an active role in dealing with these cases. In this regard, missions during 2000 to Colombia, the Democratic Republic of the Congo and Nigeria found the situation in each case significantly improved.

And finally, the first meeting of the Incident Reporting System for Research Reactors was held in 2000. This system aims to provide for

such reactors similar benefits to those provided by the Incident Reporting System for nuclear power plants. At present, 27 Member States are participating in the system.

REGULATORY ACTIVITIES RELATED TO NUCLEAR SAFETY

The International Regulatory Review Team (IRRT) service focuses on the regulation of nuclear power plants and research reactors (see the Annex, Table A10). However, the service now addresses, on request from Member States, the regulation of radiation, radioactive waste and transport safety. Following observations made by the First Review Meeting of the Convention on Nuclear Safety, special attention is being given to the de jure and de facto independence of the regulatory body and to financial and human resources. Many of the recommendations for improvement made during IRRT missions are specific to the particular national circumstances. However, some issues of more general interest are:

- The need for legislation to provide clear definition of the roles and responsibilities of all governmental bodies involved in the regulatory process, and to give the bodies the appropriate authority to meet these responsibilities;
- The need to ensure that the resources allocated to the regulatory body are adequate for it to function effectively;
- The importance of effective co-ordination between different regulatory bodies responsible for different aspects of a facility or activity;
- The role that the regulatory body plays in the development of safety culture in the plant operating organizations.

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The Incident Reporting System (IRS), operated jointly with the OECD/NEA, was established in the early 1980s to exchange information on unusual events at nuclear power plants, as well as increasing awareness of actual and potential safety problems. As shown in Fig. 1, participating countries submitted 68 reports in 2000. The reporting rate appears to be stabilizing at about 100 events per year or fewer. This number is also influenced by the fact that repetitive events that do not provide new insights are not reported to the system.

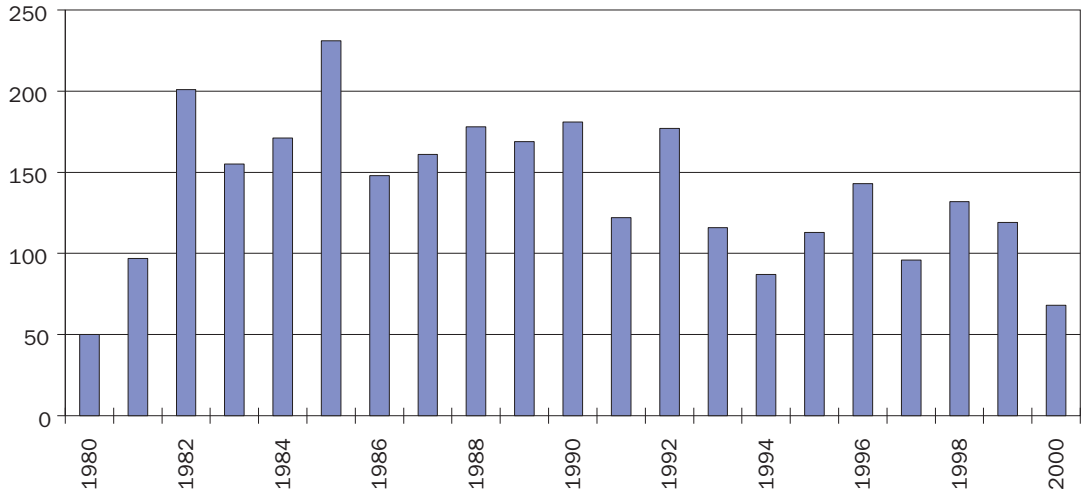

FIG. 1. Events reported to the IRS, 1980–2000.

Uncertainty about the future of nuclear power in many countries and the consequent lack of interest on the part of qualified individuals to work in the nuclear field is a major international concern. The situation is particularly worrying because higher educational opportunities in the field of nuclear engineering are greatly reduced with the elimination of nuclear engineering departments in many universities and the ageing of research facilities. On top of this the existing work force is ageing and this attrition is not being covered. In view of this situation, and in response to a resolution of the General Conference, the Agency is strengthening its training activities in the field of nuclear safety. Several new courses are being offered covering basic nuclear safety, design and operational safety, regulatory infrastructure and accident analysis. In 2000, courses were held at centres in Brazil, Germany, Slovenia and the USA. Educational modules for distance learning in nuclear safety, reactor physics and thermal hydraulics are also being prepared. In addition, a technical document was prepared on developing training programmes for staff that will assist in the systematic development of competence and training in regulatory organizations. Finally, the Agency is a member of an international task force organized by the OECD/NEA to propose actions to address this problem.