IAEA PROGRAMME ON RESEARCH REACTOR SAFETY

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ABSTRACT

This paper describes the IAEA programme on research reactor safety and includes the safety related areas of conversions to the use of low enriched uranium (LEU) fuel. The program is based on the IAEA statutory responsibilities as they apply to the requirements of over 320 research reactors operating around the world. The programme covers four major areas:

(a) the development of safety documents

(b) safety missions to research reactor facilities

(c) support of research programmes on research reactor safety

(d) support of Technical Cooperation projects on research reactor safety issues.

The demand for these activities by the IAEA member states has increased substantially in recent years especially in developing countries with increasing emphasis being placed on LEU conversion matters. In response to this demand, the IAEA has undertaken an extensive programme for each of the four areas above.

INTRODUCTION

The first research reactor was constructed more than 48 years ago and since that time approximately 535 research reactors have operated around the world. Of these about 323 are still operating in 54 countries with the distribution shown in Table 1. The operating experience exceeds 10,000 reactor-years with more than 7,000 of these on units still in operation. It should be noted that power reactors are operated in 30 countries.

These research reactors represent a wide variation in design, power level, operating mode and use ranging from critical facilities to hundreds of megawatts and from several hours of operation per week to continuous. In addition, they are operated by

Country	Number	Country	Number
Algeria	1	Korea, Rep. of	3
Argentina	5	Libyan Arab J.	1
Australia	2	Malaysia	1
Austria	3	Mexico	3
Bangladesh	1	Netherlands	2
Belgium	5	Norway	2
Brazil	4	Pakistan	2
Bulgaria	1	Peru	2
Canada	14	Philippines	1
Chile	2	Poland	3
China	10	Portugal	1
Colombia	1	Romania	2[a]
Czechoslovakia	3	South Africa	1
Dem. People's Rep. Korea	1	Sweden	2
Denmark	2	Switzerland	4
Egypt	1	Thailand	1
Finland	1	Turkey	2
France	20	USSR	24
German Dem. Rep.	5	UK	15
Germany, Fed. Rep.	21	USA	93
Greece	2	Venezuela	1
Hungary	3	Viet Nam	1
India	5	Yugoslavia	3
Indonesia	3	Zaire	1
Iran, Islamic Rep. of	1		
Iraq	2	Total	323[c]
Israel	2[a]		
Italy	7[b]		
Jamaica	1		
Japan	18		

[a] Information incomplete.
[b] Includes a reactor of the CEC in Ispra.
[c] Total includes five research reactors in Taiwan, China.

Table 1 Research Reactors In Operation (April 1990)

organizations with very different technical and financial means ranging from small universities or research institutes to large governmental institutions. In some countries where research reactors operate there is no formal governmental regulatory body.

Most of the operating research reactors, about 70%, were placed in service more than twenty years ago. To overcome the effects of ageing many are undergoing modifications including upgradings and LEU conversions and some are undergoing safety reassessments. Figure 1 presents the age distribution of research reactors.

Since 1988, six new reactors have been commissioned: five others have been shut down. A further six are under construction and 16 are planned, almost all in developing countries.

In light of this situation, the International Atomic Energy Agency (IAEA) is giving consideration to all matters related to research reactors. The safety related activities are based on the IAEA statutory functions of

(a) establishing and adopting standards of safety and providing for their applications.

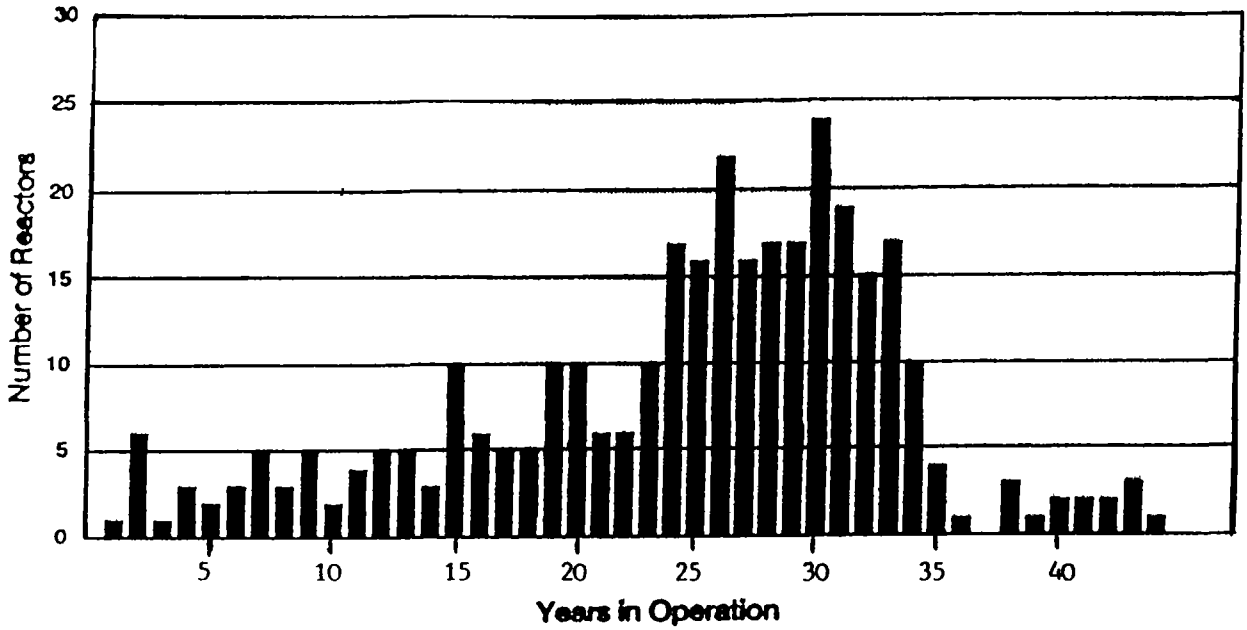

Fig. 1 Age Distribution of Research Reactors Source: IAEA Data Base

(b) fostering the exchange of technical information, scientists and experts and their training.

(c) encouraging and assisting research.

(d) making provisions of materials equipment and services to meet the needs of the above research.

In addition the statute provides for safety missions to the research reactors of member states.

To accomplish this, the IAEA is pursuing activities in four major areas as follows:

(a) the development of safety documents for research reactors.

(b) safety missions to research reactors.

(c) support of research programs on research reactor safety.

(d) support of Technical Cooperation (TC) projects on research reactor safety issues.

Over the past few years the demand from member states for these activities has increased substantially and is now expanding to include conversion to LEU and the accompanying reanalysis of safety issues. For this reason, the IAEA has active extensive programmes in each of these four areas.

DEVELOPMENT OF SAFETY DOCUMENTS FOR RESEARCH REACTORS

Since the early 1970's the IAEA has developed many reports on nuclear safety. However, most of these have been for nuclear power* and the number of safety related publications for research reactors has been small. The only IAEA Safety Series document exclusively for research reactors is a "Code of Practice on the Safe Operation of Research Reactors and Critical Assemblies" (Safety Series No. 35). This was first published in 1971 and revised in 1984 as a Safety Standard.

This is a reflection of the general situation in most countries where until recently little safety guidance has been available for research reactors including countries with well established extensive programs. To fill this gap, the IAEA has initiated a program on safety publications for research reactors and has been collecting information and experience since 1984. This program should be completed in a few years.

The program consists of the publication of a limited set of documents within the IAEA safety series to establish a consistent self-standing set of basic requirements and guidelines for the safety of research reactors. It will be modelled after the NUSS program but will be considerably reduced in scope.

Document preparation has been organized based on the new IAEA Safety Series structure approved in 1988. In this scheme, documents are grouped together into single topics called Application Areas with Research Reactor Safety being one such area. Within each application area, a hierarchy of four levels has been established these are

(a) Safety Fundamentals

(b) Safety Standards

(c) Safety Guides

(d) Safety Practices

A provisional scheme of titles for the above set is presented in Figure 2.

Safety Fundamentals

This top level is characterized by the presentation of safety concepts, safety objectives, and fundamental principles and requirements. Its content may be relevant for more than one application area. These Safety Fundamentals are umbrella documents which are implemented by lower level publications.

For the research reactor safety series no specific Safety Fundamentals document is anticipated.

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* The IAEA Nuclear Safety Standards (NUSS), 60 Codes and Standards dealing with nuclear power reactor safety.

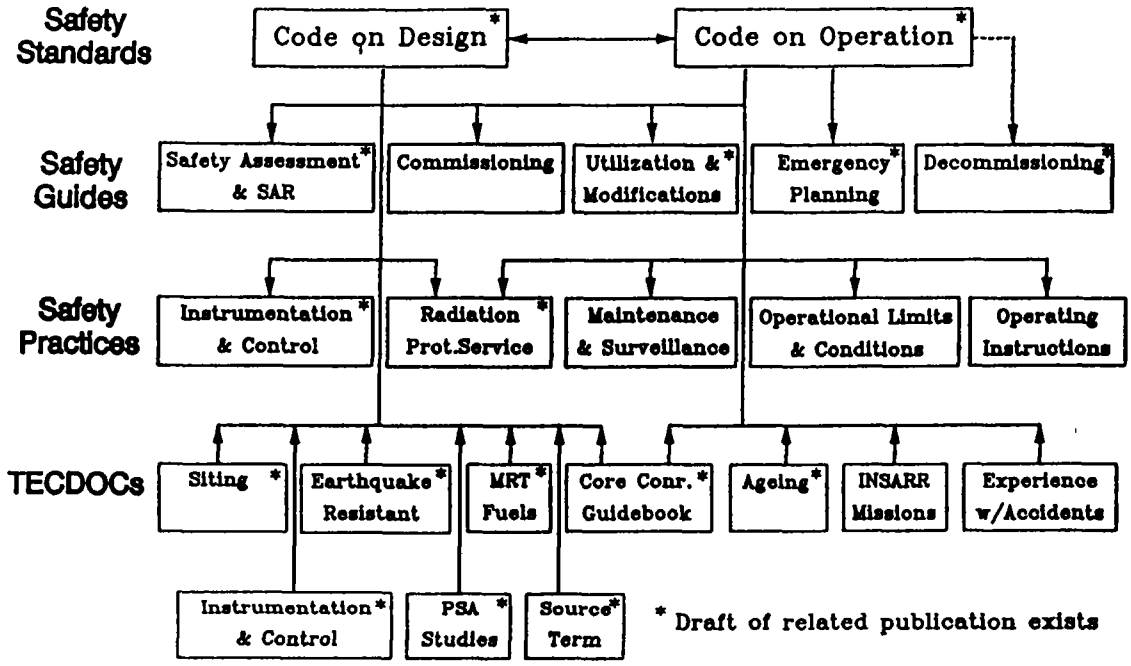

Fig. 2 Categories of IAEA Safety Publications for Research Reactors

Safety Standards

Safety standards are the top safety documents specific to individual Application Areas. They establish the basic objectives, principles and requirements (explaining what is to be done rather than how it could be done) that must be satisfied to ensure adequate safety. These requirements are formulated on the basis of a broad international consensus and represent the current state of the art of the safety of nuclear technology. These documents contain firm requirements ("shall" statements) of a mostly regulatory nature and little explanatory text or recommendations.

Only two titles in this category are anticipated for the Application Area of Research Reactor Safety:

(a) Code on the Safety of Research Reactors: Design, and

(b) Code on the Safety of Research Reactors: Operation.

These documents cover all important items of research reactor safety. The safety aspects related to design and operation have been emphasized in relationship to those related to siting, regulatory supervision, and quality assurance because of the wide variation in research reactors.

The documents are intended to cover all research reactors already built or under design and construction. However, safety issues applicable to very specific reactor types

(for example, test reactors) are not necessarily covered in these codes. Some of the recommendations in the safety standard are also not directly applicable to very small research reactors. For these cases, the requirements can be interpreted as mere recommendations.

Code on the Safety of Nuclear Research Reactors: Design

The Safety Standard on Design has been prepared and its main objective is to provide a safety basis for the design of a research reactor and for the assessment of the design. Another objective is to cover regulatory supervision and siting, as far as they are related to activities for the design of the reactor.

The scope of the standard is broad and only those specific design principles relevant to the reactor under consideration need be adopted. These principles can form the foundation on which an IAEA member state may develop specific criteria for its reactor.

The principle embodied in this document shall be applied to the design of new research reactors and should also apply to existing ones to the extent that is reasonably practical. The recommendations of this Safety Standard will be followed in all the IAEA assisted projects concerning the siting, design, construction, commissioning, experimental design or safety evaluation of research reactors.

This Safety Standard has been structured taking into account its role in the coverage of all important items regarding the safety design of research reactors. It consists of six sections and two appendices as shown in Table 2.

Section 1, introducing the document, defines the objectives and scope and presents its structure. Section 2, making reference to the IAEA Safety Fundamental, introduces the general objectives concerning the radiological and nuclear safety of research reactors and describes the approach used in this document for their achievement. Section 3 deals with general requirements regarding regulatory supervision as far as they are related to the design of research reactors. In this section some guidance on the first steps of the licensing process of research reactors is also included. Section 4 provides some general statements and requirements regarding the selection and evaluation of the reactor site as far as they concern the reactor design or are related to the licensing process of the reactor. Section 5 describes the general design principles applicable to all types of research reactors. Section 6 deals with the specific design principles as appropriate for a given research reactor. Appendix A provides a list of the selected postulated initiating events to be considered in the safety analysis of any research reactor. Finally, Appendix B presents a list with the safety functions attributed to the safety systems and other safety related items normally included in the research reactor design.

Code on the Safety of Nuclear Research Reactors: Operation

The Safety Standard on Operation has been prepared and is based on the existing document Safety Series No. 35, 1984 edition. The document covers all aspects of safe operations of a reactor including regulatory supervision and the application of a quality assurance program.

The main objective of this document is to provide general and specific principles and requirements for the safe operation of a research reactor, with emphasis on the supervision and managerial aspects. However, the document also provides some guidance and information on topics concerning all the organizations involved in the operation, namely: operating organization, regulatory body, users, and other organizations.

The objectives are accomplished by providing safety principles and requirements. In addition to the requirements mentioned above the statement stresses operating procedure reviews and audits and personal history training and retraining. Together with the safety standard on design, this standard on operation must cover all items important to safety during the entire life cycle of a research reactor.

Table 3 presents the table of contents for this standard. The eleven chapters of the document cover all stages of the reactor lifetime from an operational standpoint. Those topics not covered further by a safety guide have been developed in detail. Although not shown in the table of contents, important aspects of reactor management are included.

Safety Guides

Safety Guides implement documents of a higher level, usually Safety Standards and provide recommendations on how to carry out the requirements of the Standards. These recommendations may be written in an obligatory format; they will contain considerable background information and be in less formal language than in the Standard.

Five Safety Guides are anticipated as follows:

(a) Safety Assessment and Safety Analysis Report of Research Reactors,

(b) Modifications and Experiments of Research Reactors,

(c) Emergency Planning and Preparedness of Research Reactors,

(d) Commissioning of Research Reactors

(e) Decommissioning of Research Reactors.

The Safety Guide on decommissioning has already been published*,but it will probably be reviewed to convert it to safety practice.

The guide for Safety Assessment and Safety Analysis Report, Modifications and Experiments and Emergency Planning are well along. The preparation of the guide on commissioning has not begun.

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* Safety in Decommissioning of Research Reactors, Safety Series No. 74, IAEA, Vienna, 1986.

Table 2 Table of Contents of the Code on the Safety of Nuclear Research Reactors: Design

Table 3 Table of Contents of the Code on the Safety of Nuclear Research Reactors: Operations

Safety Practices

Safety Practices are new documents in the IAEA Safety Series Publication which give practical examples and detailed methods regarding procedures and techniques, and can be used for the implementation of Safety Guides or Standards. They may show how to perform a specific calculation, may suggest some forms to be used in an auditing process, or give a collection of data. The following titles have been anticipated in this category:

(a) Limits and Conditions for Research Reactors

(b) Instrumentation and Control for Research Reactors

(c) Radiation Protection Service for Research Reactors

(d) Maintenance and Repair for Research Reactors

(e) Operating Procedures for Research Reactors

There are drafts available with different degree of development for documents (b) and (c)

Technical Documents

Finally, the new IAEA Safety Series Publications foresee other safety-related documents, which may contain certain topics additional to those on safety and which are not predominantly written to ensure safety. These documents are designated either as a Technical Report or as a Technical Document (TECDOC). The Agency has already published a number of these TECDOCs covering topics on siting, upgrading, core conversion, and probablistic safety assessment for research reactors.

Production Process for Safety Series Documents

The production process for safety documents has been designed to meet the following objectives:

(a) to develop for the user an identifiable, coordinated package of documents pertinent to each Application Area;

(b) to develop the technical content of individual documents with required quality and degree of international consensus;

(c) to ensure that the format and language style are consistent with the level of the individual document;

(d) to approve and promulgate the documents using techniques appropriate to the documents position in the hierarchy;

(e) to use the Member States' expert input and Secretariat expertise in the most effective and efficient manner.

While the main thrust, technical approach and composition of the documents may be the result of proposals by the IAEA technical staff, the initial drafts are prepared by external Consultants Services (CS). These drafts are reviewed and revised by Advisory Groups (AG) or Technical Committees (TC). To obtain international consensus on content, Safety Fundamentals, Standards and Guides are reviewed by a Technical Committee with international membership. These documents are also reviewed by member states whose comments are incorporated into the drafts by the TC.

The final draft is sent for internal review to the IAEA Safety Review Committee (SSRC) and the Publication Committee. Finally, the revised draft is published with the approval of the Board of Governors (Safety Fundamentals and Standards) or under the authority of the Director General of the IAEA.

Figure 3 is a matrix showing these arrangements.

PC - Publications Committee
BG - Board of Governors
TC - Technical Committee
AG - ADVISORY GROUP

	SAFETY FUNDAMENTALS	SAFETY STANDARDS	SAFETY GUIDES	SAFETY PRACTICES	TECHNICAL DOCUMENTS	TECDOCS
IAEA TECHNICAL OFFICERS INITIATE TECHNICAL PROPOSALS	X	X	X	X	X	X
CLEARANCE FOR PRODUCTION PLAN, DOCUMENT CATEGORIZATION, ETC., BY SAFETTY SERIES REVIEW COMMITTEE	X	X	X	X	X	X
CONSULTANT SERVICES TO DRAFT AND REVISE TEXT	X	X	X	X	X	X
FORMAL MEMBER STATES COMMENTS	X	X	OPTIONAL	-	-	-
TECHNICAL COMMITTEE/ADVISORY GROUP TO VERIFY THRUST, TECHNICAL APPROACH	X	X	TC	TC/AG	X	-
SSRC TO CONFIRM CATEGORI-ZATION, QUALITY, STYLE, ETC.	X	X	X	X	-	-
RELEASE FOR PUBLICATION	PC/BG	PC/BG	PC	PC	PC	PC

Fig. 3 Production Process for Safety Documents

PERFORMANCE OF SAFETY MISSIONS TO RESEARCH REACTORS

IAEA statutes and rules* consider the possibility of sending safety missions with various objectives to Member States. The most usual mission is one whose purpose is to provide advice and assistance with the application of IAEA Safety Standards and measures to agency assisted projects.

Since 1972, at the request of a Member State, Integrated Safety Assessment of Research Reactor (INSARR) missions have been conducted. The objective of these missions is to conduct a comprehensive and independent integrated safety assessment of

* Art.III.A.6. and XII
INFCIRC/18/Rev.1, The Agency's Safety Standards and Measures, IAEA, Vienna, 1976

the research reactor facility to assess the safety of the reactor against the Agency's standards. The safety evaluation is also aimed at facilitating an exchange of knowledge and experience between the experts and reactor personnel. These missions are not intended as regulatory type inspections that check compliance with national requirements; however, the missions are usually conducted with the cooperation of the relevant national regulatory staff.

INSARR missions are available to all Member States where a research reactor is in operation or is close to operation. The safety assessment performed during the mission may cover just the operational safety of the reactor or may assess the whole safety to support the licensing process for the reactor, including its commissioning and decommissioning.

INSARR missions consist normally of two to four experts, including staff members and outside experts. The minimum duration of the INSARR is three whole working days at the site, if sufficient information on the facility was provided in advance.

At the site the mission team will:

(a) examine the safety documentation of the facility

(b) review the operational status of the reactor, conducting a thorough visit to the facility and observing, if possible, a reactor start up and shutdown; and

(c) discuss technical details with the responsible personnel.

Normally the operating organization is requested to complete a questionnaire and other material on nuclear safety and radiation protection aspects of the operation of the research reactor. However, depending on the specific objective of the INSARR mission, additional information may be required. This information may include:

(a) the structure of the administrative organization set up by the State for dealing with safety matters and the national licensing process, including details on the evaluating procedures, records keeping, inspections and supervisory examinations;

(b) the safety analysis report (SAR) or a similar document prepared with the same purpose containing information such as siting, organization and training programme for personnel, safety criteria, quality assurance, safety systems, engineering safety systems, operating procedures for normal and accidental conditions, waste management and emergency planning and preparedness.

At the end of the INSARR mission, the team conveys its preliminary conclusions and recommendations to the relevant authorities (operating organization and regulatory body) at an exit meeting. Shortly afterwards, a final mission report is submitted through official channels to the Member State concerned.

INSARR missions are Agency services, normally cost-free to Member States which are developing countries. The cost of an INSARR mission requested by other countries or a special INSARR mission dealing with issues other than the ones normally reviewed are discussed on a case-by-case basis with the requesting Member State.

As of the end of April 1991, a total of 99 INSARR missions had taken place in 30 Member States. Twenty-three of these countries maintained their facilities under agreement with the Agency and seven countries requested INSARR missions to facilities not covered by agreements with the Agency. The distribution of safety missions is shown in Table 4.

	1981-1985	1986-1990	1991-1995
Brazil			1991
Bulgaria		1990	
Chile		1986	1991 (2)
Colombia	1983	1987	
Egypt	1985		
Finland	1981	1987	
Greece	1982	1986	
Hungary		1989	
Indonesia	1982 (2)	1986 (2)	
Iran, Islam Rep		1990	
Iraq		1988 (2)	
Jamaica		1986	
Korea, Rep	1982 (2)	1988 (2)	
Malaysia	1982	1986	
Mexico	1981 (4)	1986 (4)	
Norway		1987, 1988	
Pakistan	1985		
Peru	1981	1987	
Philippines	1983		
Romania	1983		
Spain	1982	1986	
Thailand	1982	1987	
Turkey		1986	
Ukrainian SSR			1991
USSR		1990 (2)	
Uruguay	1984		
Venezuela	1984	1988	
Viet Nam	1985	1989	
Yugoslavia	1985 (2)		
Zaire	1984		

Note: The number of facilities reviewed, if more than one, is given in parentheses.

Table 4 INSARR and Other IAEA Missions to Research Reactors between 1981 and April 1991

Coordinated Research Programmes

To encourage and assist research, the exchange of scientific and technical information, and the training of nuclear scientists, the IAEA supports Coordinated Research Programs (CRP) dealing with well defined research reactor safety topics. These CPR's are developed as a result of recommendations made by groups of experts who have been requested to advise the Agency on a specific research subject.

The IAEA usually establishes contracts (funded from the Agency's regular budget) or agreements (free of charge for the Agency) with institutions from developing or industrialised countries. The specific tasks related to the CRP objectives to be developed by each institution participating in the CRP are described in these contracts or agreements. Each institution nominates a Chief Scientific Investigator who takes the responsibility for the research work. The Agency appoints a staff member as a Project Officer who takes all the responsibilities related to technical matters: contacting the institutions which may have an interest in participating, evaluating the contracts and proposals related to the programme and covering the Research Co-ordination Meetings (RCM).

The RCM are financed by the Agency and are convened regularly to define the objectives and lines of the project, to follow up the progress and contributions of each participant, and to exchange information and suggestions. The final RCM provides for an international evaluation for the CRP and for the preparation of the final documents for publication.

Recently, the IAEA published the results of an earlier completed CRP that brought together 13 institutions from 12 countries to work on the use of Probabilistic Safety Assessment (PSA) in analysing safety features of research reactors. The document, called "Application of PSA to Research Reactors", consists of a summary (TECDOC-517) and three volumes. The summary contains directions of practical use that enable the analyst to tackle the problem by giving soundly based advice illustrated with references to specific case studies, which were the individual contributions to the CRP.

A major finding of this international effort was the dearth of databases suitable for use in numerical calculations related to PSA studies on research reactors. To help overcome this deficiency, the Agency has initiated a new CRP on data acquisition for PSA studies of research reactors. The first RCM was held in Vienna in October 1989 with the participation of institutions from nine countries. The main objective of the meeting was to define a strategy for the systematic collection and classification of reliable data to be used in PSA studies of research reactors.

Individual Research Contracts

These contracts provide financial support for research projects which will further the Agency's research program for research reactors. These contracts may be for individual research or as part of a CRP.

The financial support for a contract consists of approximately $5000/year. The duration of the contract is one year renewable up to three years. At the end of the contract, the contractor submits a final report. In the case of contract renewal, a progress report accompanies each renewal application. Part of the funds provided by the Agency may be used by the contractor for purchase of equipment required in connection with the contract.

At present, the Agency is sponsoring several research contracts. All of these are related to the CRP on PSA or are individual contracts on Data Acquisition for use in PSA studies.

International Meetings and Training Courses

To facilitate the exchange of information and the training of nuclear scientists, the IAEA organizes and sponsors major international meetings and training courses. The most recent of these are

(a) International Symposium on Research Reactor Safety, Operations and Modifications, Chalk River, Ontario, Canada, October, 1989 under the auspices of the Atomic Energy of Canada Limited and the IAEA.

(b) Interregional Training Course on Safety in the Operation of Research Reactors, Argonne, Illinois, USA, 14 May to 15 June 1990 in cooperation with the Argonne National Laboratory and the Government of the United States of America.

(c) Local Training Course in the Safe Operation of Research Reactors, Iran, February-March 1991.

(d) Regional Training Course on Regulatory Aspects and Safety Documentation for Research Reactors, Chile, August-September 1991.

SUPPORT TO TECHNICAL COOPERATION PROJECTS ON RESEARCH REACTOR SAFETY ISSUES

Based on its function of making provision for materials, services, equipment and facilities to meet the needs of research on atomic energy for peaceful uses, the IAEA is

assisting numerous technical projects on specific topics related to the safety of research reactors. The assisted technical projects are funded from the Agency's regular budget or financed by extra-budgetary contributions from other Member States or institutions.

At present the Agency has assisted projects related to research reactor safety in Albania, Bulgaria, Columbia, Egypt, Greece, Hungary, Indonesia, Iran, Iraq, Morocco, Peru, the Philippines, Portugal, Syria, Thailand, Venezuela, Vietnam, Yugoslavia, and Zaire.

The above projects differs a great deal from each other in that the objectives may range from the provision of technical and financial assistance for constructing a new research reactor (Albania) or the undertaking of large modification projects (Hungary, Portugal) to providing the facility with small equipment or specific expert advice.

FUTURE ACTIVITIES

In the four major areas mentioned above, the activities of the IAEA will be as follows.

Development of Safety Documents

It is anticipated that the publication of the two standards the guides on the preparation of the safety analysis report and experiments and modification will be ready for publication in the next year. Work has begun on a TECDOC on ageing, performance of INSARR missions and peer review and experience with accidents.

INSARR Missions

In 1992 as many as 9 INSARR missions are planned. Some of the 24 reactors under a special agreement with the IAEA are included in this number.

Support of Research Programs

It is anticipated that data acquisition for PSA for research reactors will continue.

Support to Technical Cooperation Projects

In 1992, two regional courses are planned

(a) Upgrading the Safety Analysis for a Research Reactor, European location

(b) Safe Operation of a Research Reactor, Paris, November 1992

In 1993 it is expected that the Argonne course will be repeated.

New activities will include

(a) Assistance in the expansion of the International Nuclear Event Scale (INES) to non-power reactors

(b) Creation of an Incident Reporting System (IRSRR) for Research Reactors.