SIXTH RCA WORKING GROUP MEETING

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SIXTH WORKING GROUP MEETING
OF RCA MEMBER STATES

Kalpakkam, India
March 20-23, 1984

SUMMARY REPORT

The 6th Working Group Meeting of Member States of RCA (Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology) was held at the Reactor Research Centre, Kalpakkam, near Madras, India, March 20 to 23, 1984. The meeting was hosted by the Department of Atomic Energy of the Government of India and was attended by representatives from 8 RCA Member States. A list of participants is attached as Appendix 1.

Mr. C.V. Sundaram, Director, Reactor Research Centre, Kalpakkam, Department of Atomic Energy, India, welcomed the delegates and introduced the participants. He also briefly explained about the various activities of the Centre. His remarks are attached as Appendix 2.

Professor M. Zifferero, Deputy Director General and Head of the Department of Research and Isotopes, International Atomic Energy Agency, traced the history of RCA and reviewed its current activities in his opening remarks (Appendix 3). Prof. Zifferero pointed out that IAEA is putting ever increasing emphasis on RCA activities and that, to facilitate this task, a full time Co-ordinator had been appointed, at the level of Director, in the person of Dr. M. Kobayashi.

Dr. R. Ramanna, Chairman of the Atomic Energy Commission of India and Secretary to the Department of Atomic Energy, Government of India, in his inaugural address recalled the active role played by India in RCA activities. He drew attention to the common problems of introducing nuclear power in developing countries and suggested that RCA should address itself to co-operative aspects of this question (Appendix 4). Dr. D.V. Gopinath, Head, SRL, Reactor Research Centre, presented a vote of thanks on behalf of the Local Organizing Committee for the Working Group Meeting. It is attached as Appendix 5.

Following the opening of the meeting, Dr. P.K. Iyengar, Director, Bhabha Atomic Research Centre, Bombay, was unanimously elected Chairman of the meeting. His name was proposed by the representative of Japan and seconded by the representatives of Australia and the Republic of Korea. Dr. Iyengar thanked the representatives of the Member States and re-emphasized the need for greater co-operation among RCA countries. While appreciating the considerable efforts already put into RCA by Member States in the field of isotope applications in agriculture, medicine and industry, he felt that it would be desirable to develop good programmes in basic research. In this context, he suggested that a team of scientists drawn from various Member States might form a research group and work on specific projects in designated laboratories in Member States under guidance for durations of six months or more.

The provisional schedule of the meeting was circulated and accepted.

AGENDA ITEM I

Progress of RCA Research Projects

A status report of co-operative research projects for the years 1983-84 was presented by Dr. M. Kobayashi, RCA Co-ordinator of IAEA. The report is attached as Appendix 6.

The representatives of Member States generally expressed satisfaction with the progress made in the various research projects. The discussions regarding individual research projects are summarized below:

1. Use of induced mutations for improvement of grain legume production

In view of the good progress achieved thus far in this project, it was agreed to extend the duration of the programme until 1986.

2. Food Irradiation Phase I

The participants expressed the view that in most countries the food irradiation programme had reached a stage where it can be transferred on a pilot-plant or industrial scale for specific commodities. Copies of the revised version of the Recommended Codex International General Standard for Irradiated Foods were made available by the IAEA Secretariat to serve as guidelines in formulating national standards (Appendix 7).

3. Nuclear techniques to improve domestic buffalo production Phase I

While generally appreciating the progress made in this project, the representatives from India and Thailand desired that specific accomplishment should be highlighted.

4. Radiation sterilization practices for medical supplies

The project was completed in 1983 with the compilation of a code of practice. The Indian representative requested that copies of the recommended code of practice prepared previously by the Agency and further outlined in a coordinated research programme in 1983 should be made available to all RCA Member States. He also expressed the view that further updating of the code of practice should depend on the outcome of further international efforts.

5. Health-related environmental research

It was noted that upon successful completion of the project, it was phased out by the end of March 1984.

6. Maintenance of nuclear instruments

Comments made by participants included the following: a) IAEA should consider establishing a "spare parts" bank to provide urgent supply of spare parts of nuclear instruments to Member States; b) it was felt that sufficient emphasis had been given to areas like air conditioning and power fluctuation and that these need not be further stressed in future training programmes; c) the representatives from India and Thailand suggested that training programmes in the field of maintenance of industrial nucleonic control systems are important and should be given adequate attention; d) the Deputy Director General, Department of Research and Isotopes, IAEA, informed the participants that the Agency is considering to conduct, at its laboratory at Seibersdorf near Vienna, quality control of all nuclear instruments to be supplied under the Agency's technical co-operation programme.

7. Basic science using research reactors

A report on the IAEA-RCA Workshop on the use of microprocessors in research reactor utilization, held in early 1984 at the Bhabha Atomic Research Centre, India, was presented by the Indian representative. The report is attached as Appendix 8. The members appreciated the useful programme of the course and felt that similar workshops should be held in future. The use of personal computers in analysing scientific data might also be included in the future programmes.

8. Isotope application in hydrology and sedimentology

The Australian representative expressed the view that the countries participating in this programme have reached a stage where further cash contributions to the programme will not be needed. Hence, he informed that future Australian contributions to this programme may be "in kind" contributions. The representative of Malaysia agreed with this view.

9. Other on-going projects

The participants approved the progress reports on the ongoing programmes related to semi-dwarf mutants for rice improvement, cancer therapy, tropical parasitic diseases, and production of Tc-99m generators, which were included in the background document prepared by the IAEA secretariat.

AGENDA ITEM II

Progress of the RCA/UNDP Industrial Project

A summary of progress achieved was presented by the RCA Co-ordinator. The Japanese representative reported on Japanese co-operation in 1983/84 and expressed the intention of his government to make every possible effort to continue this co-operation.

Unfortunately, the Project Co-ordinator, Mr. Sobhak Kasemsanta, was able to attend the 6th Working Group meeting only for one day (March 22) and the detailed discussions were postponed until his arrival. The report and work plan were presented by Mr. Kasemsanta during the session held on March 22. The text of Mr. Kasemsanta's presentation is included as Appendix 9.

The Indian representative pointed out the usefulness of the various sub-projects of the UNDP Industrial Project, and especially noted the training/demonstration programmes. He gave a detailed progress report of the training programmes conducted in India and other countries, particularly in tracer technology (India and Singapore), radiation sterilization (India and Republic of Korea), and nucleonic control systems in the steel industry (India and Japan). He made two further observations: Regarding the annual budget, it was, he said, important that the national counterparts be consulted before any major changes in individual sub-projects are made. He suggested proceeding with caution regarding market survey studies for radiation equipment and nucleonic systems. While some of the sub-projects are at a mature stage, e.g. nucleonic systems in the paper industry, in some other programmes such as application of electron beam processing, no equipment has been installed yet and the first training/demonstration has yet to take place. Also, the technology for radiation vulcanization of rubber is not yet completed and the sub-project is not ready for technology transfer.

Industries in developing countries are just becoming aware of the value of electron beam machines. Market surveys will be more meaningful after about one year when the above technologies are established and the first series of executive management seminars in different sectors is completed.

The representative of Malaysia generally agreed with the need to establish a demonstration programme before the market survey was carried out. The representative of Bangladesh emphasized the need for an intensive train-the-trainers programme. The IAEA representative suggested that national agencies should take care in the selection of candidates for training and mentioned that the Senior Board of Advisors had suggested that about 70% should be from industry and 30% from national centres. It was generally agreed that the training/demonstration programmes were useful and that survey studies should be taken up only after careful planning at the appropriate time.

To optimize the benefits of the training courses, it was recommended that follow-up action be taken on the continuing engagement of the trainees in their respective areas of specialization.

AGENDA ITEM III

Action Plan for 1984 and Cost Projection for 1985

The 1984 RCA action plan and 1985 cost projection were presented by the IAEA secretariat. (Appendix 10). The total budget for RCA projects in 1984 is US$2,454,559. Of this amount, the budget for research projects amounts to US$833,500 and that for the UNDP industrial projects to US$1,621,059. The representatives expressed their great appreciation of the IAEA's continuing financial support to RCA and urged strong support for the activities planned for 1984 and 1985. Certain representatives enquired about relative priorities of the various projects under the RCA research programmes and the flexibility existing to respond to such priorities. The DDG-RI, IAEA, clarified that, within the total allocation limit, re-allocation to different projects is possible and can be done to meet the wishes of RCA Working Group members. It was agreed that a system for the evaluation of the projects and for establishing priorities should be established. The achievements in the projects should also be highlighted in such evaluations.

AGENDA ITEM IV

Basic Science for Advanced Reactors

In the context of RCA programmes and basic sciences and research reactor utilization, Mr. C.V. Sundaram, Director of the Reactor Research Centre, gave a presentation on the research programme carried out at the Kalpakkam Centre and highlighted some of the important areas of basic research necessary for advanced reactors.

AGENDA ITEM V

Medical and Biological Applications of Nuclear Techniques (Revised)

After reviewing Japanese cooperation in RCA, including JICA's activities, the Japanese representative stated that his government would support the project, especially in the fields of nuclear medicine and cancer therapy. A draft agreement is being prepared similar to the Agreement for the Food Irradiation Project, with an expectation of wider participation of RCA Member States. He also explained the results of radiation treatment of cancer under hyperthermic conditions and using sensitizers, and emphasized the relative cost advantage of hyperthermic machines in comparison with high LET radiation techniques which require expensive cyclotrons. The representative from Korea urged to caution as this technique is still in a research and development state.

Within the co-operative research project on nuclear medicine for liver and thyroid diseases, it was proposed, based on the recommendation of a recently IAEA consultants' meeting, to initiate a programme on "Imaging procedures for the diagnosis of liver diseases". The revised proposal, along with revised budget estimates, is attached as Appendix 11. In the revised programme, the envisaged training programme on radioimmunoassay techniques for thyroid hormones will be held in 1985 by IAEA, possibly with the support of the Australian government. The Indian representative informed that training programmes in RIA techniques are held regularly in India. He also said that the possibility of including candidates from RCA countries in one of the regular training courses or even conducting a special training course for them could be examined in 1985.

The representative from Korea indicated that the Specialists' meeting on imaging procedures for diagnosis of liver diseases under this project will be held at Seoul as proposed, pending final approval of his government. He also informed that the meeting could be held during the first week of September 1984, following the Asia-Oceanian Congress of Nuclear Medicine, scheduled to be held in Seoul from 27-31 August, 1984.

AGENDA ITEM VI

Nuclear Techniques to Improve Domestic Buffalo Production Phase II

In view of the good progress achieved in Phase I of this programme, it was decided to implement Phase II of the project. However, it was felt that the work plan as envisaged covers too many areas and it may be advisable, considering the limited resources available, to concentrate on selected areas such as nutritional aspects. It was felt that IAEA should consider this aspect at the time of awarding the contracts.

AGENDA ITEM VII

Future Programmes and New Proposals

1. Food Irradiation Phase II

The representative from Bangladesh announced that an irradiator from USSR would be provided to his country under the IAEA technical cooperation programme, and he offered its use to other Member States of RCA. He also announced that irradiated food had been cleared for human consumption in his country. The representative from Thailand informed that the present trend in his country is towards commercialization of food irradiation (onions and potatoes) in the private sector.

The representative from India said that the objectives and work plan as outlined may require certain modifications. The objective outlined in point 1.1 of the document prepared by the IAEA secretariat may be modified so that food irradiation technology should be applied to products carefully selected to suit the needs of the region. From this point of view, the insect disinfectation of fruits would receive lower priority. He also pointed out that the irradiation of frozen sea food would need to be dove-tailed into the existing technology and hence the economics would have to be carefully examined. He felt that priority should be given to areas like the study of transport of irradiated foods within the region, their market testing, consumer acceptance, and economic evaluation. Most Member States expressed strong support for this programme and welcomed the trend towards commercialization. The delegate of Australia announced that the Australian Government is considering the possibility of extending financial support to Phase II of the project.

2. Energy from Agricultural and Agro-Industrial Residues through the Use of Radiation and Industrial Micro-organisms

After a brief introduction by the IAEA secretariat, the Bangladesh representative presented the project proposal. (Appendix 12). The DDG-RI, IAEA, expressed the view that this project, although of great significance for the energy needs of developing countries, contained only a small nuclear component for consideration by IAEA as a coordinated research programme. The position may be reviewed after the scope of activities of other UN organizations in this area has been examined, to avoid a conflict of interest. However, it would be possible to consider, on its own merits, any individual research contract proposal for any specific component of the programme involving major use of radiation techniques.

3. Other New Proposals

A proposal for conducting a workshop on "Reactor neutron activation analysis" under the reactor utilization programme of RCA was presented by the Indian participant. The detailed proposal is attached as Appendix 13. The course is planned for a duration of 2-3 weeks and will be funded from India's special contribution to RCA. The Indian representative also indicated his country's willingness to share the neutron beam facilities available in Indian research reactors and associated instruments with other RCA countries for use in research programmes. The representatives of Malaysia, Bangladesh and the DDG-RI, IAEA, fully supported this proposal since it would be beneficial in the utilization of research reactors. The proposal was accepted.

AGENDA ITEM VIII

Country Statements by RCA Representatives

The country statements presented by the representatives are attached as Appendix 14.

SIXTH RCA WORKING GROUP MEETING

AGENDA

March 20

Inaugural session

9:30 - 10:45	Welcome address	- Mr. C.V. Sundaram
	Opening remarks	- Mr. M. Zifferero
	Inaugural address	- Mr. R. Ramanna
	Vote of thanks	- Dr. D.V. Gopinath

Technical sessions

Session 1

10:45 - 12:45

Election of Chairman
Comments by Chairman-elect
Adoption of Agenda
Progress of RCA Research Projects 1983/84
Progress of UNDP Industrial Project 1983/84

Lunch

Session 2

14:15 - 16:00 Action Plan for 1984 and Cost Projection 1985

16:00 - 17:00 "Unification of the Forces of Nature"
Talk by Prof. G. Rajasekaran, Jt. Director
MATSCIENCE, Madras

March 21

Session 3

9:30 - 12:45

Basic Science using Research Reactors
Medical and Biological Applications of Nuclear Techniques
Improvement of Buffalo Production

Lunch

Session 4

14:15 - 17:00	Future Programmes and New Proposals
	Food Irradiation Energy from Agricultural and Agro-industrial Residues through the Use of Radiation and Industrial Microorganisms Other new proposals
	Country statements
19:00 - 20:30	Cultural programme

March 22

9:30 - 10:30	Discussions on the UNDP Industrial Project
10:30 - 13:00	Visit to Madras Atomic Power Station and Reactor Research Centre
	Afternoon free

March 23

Closing Session

9:30 - 11:00	Other Business
	Presentation and acceptance of minutes
	Closing remarks
	Adjournment

Appendix 1

SIXTH WORKING GROUP MEETING
of
RCA MEMBER STATES

Kalpakkam, India
March 20-23, 1984

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Appendix 2

SIXTH RCA WORKING GROUP MEETING

WELCOME ADDRESS

Shri C.V. Sundaram
Director, Research Reactor Centre

Dr. Ramanna, Professor Zifferero, distinguished guests from overseas, fellow participants and colleagues.

On behalf of the Reactor Research Centre, Kalpakkam, it is my very pleasant duty to welcome you all here to this inaugural function of the Annual Meeting of the Working Group of the Regional Cooperative Agreement (RCA) of IAEA.

This is the 6th Meeting of the RCA Working Group since its formation in 1979, the earlier meetings having been held in Tokyo, Manila, Jakarta, Kuala Lumpur and Dhaka.

The Department of Atomic Energy, India, has always greatly valued international cooperation in the peaceful utilization of atomic energy for development. It has shown keen interest in the deliberations of IAEA and actively participated in the IAEA projects calling for international collaboration. During the 5th RCA Working Group Meeting held last year in Dhaka, the representative from India formally extended the Indian invitation to host the 1984 meeting and this proposal received the concurrence of representatives of the other countries. We are grateful to the IAEA and the RCA Member States for their readiness in accepting this invitation which has brought this group to Kalpakkam.

We are particularly happy that this meeting is being inaugurated by Dr. Ramanna, Chairman of the Atomic Energy Commission. Through his pioneering contributions in nuclear science and technology, his deep conviction in the importance of nuclear energy development for human progress, and his infinite capacity for integrating a wide range of cultural values of evolving a philosophy for purposeful action, Dr. Ramanna represents a vital and invigorating force, not only for India but in the entire international scene today. He has been a consistent champion of enlightened self-reliance and enlightened international collaboration in the community of human endeavour, in the cause of human civilisation. We will keenly look forward to his message for our meeting.

We are very happy that Professor Zifferero and Dr. Kobayashi from the IAEA and Mr. S.K. Singh, the Indian Ambassador in Vienna, are attending this meeting, and I extend our hearty welcome to them. Professor Zifferero is Deputy Director General and Head of the Department of Research and Isotopes, IAEA. He has been associated with the Italian atomic energy programme for nearly three decades. He has specialized in aspects related to the fuel cycle, particularly fuel reprocessing, and brings a large fund of experience to his present assignment in IAEA and RCA which will bring benefits to the programme.

Participating in this meeting are representatives from nine countries from Asia and the Pacific region. I realize that for many of you the notice for this meeting was rather short and that could have posed problems in organizing your schedule. We particularly appreciate that you have been able to be with us despite these difficulties. I am sure that Dr. Gopinath and his colleagues in the Local Organizing Committee will spare no effort in ensuring that your stay is comfortable and enjoyable.

In the Indian team for this meeting, we have 13 participants from BARC and RRC. I should like to make special reference to Dr. P.K. Iyengar, Director, BARC, Dr. V.K. Iya, Director, Isotope Group, BARC, and Dr. K. Sundaram, Director, Biomedical Group, BARC, who have been illustrious and dynamic leaders in the programmes in physics, isotope applications and the life sciences and whose individual contributions have had a strong impact on RCA programmes in the region.

While welcoming you all to this function, it will be appropriate for me to add a few words also about this Centre. The Reactor Research Centre came into existence in 1972, around the same time the RCA was established. Considering the high potential of fast reactors for nuclear power in the effective utilization of uranium and thorium resources, the Department of Atomic Energy has placed emphasis on the development of fast reactor technology. To build up the necessary infrastructure, this Centre was started originally with a nucleus of scientists from BARC. Presently, we have the Fast Breeder Test Reactor in an advanced stage of completion and it is expected to go into operation towards the end of this year. We have operating laboratories working on the various aspects of fast reactor development such as materials science, materials development, reprocessing development, radiochemistry, safety research, and sodium technology.

As you will have noticed from the provisional agenda of the meeting, we have a programme of taking you around the Madras Atomic Power Station and the Reactor Research Centre. Besides this, during the course of your stay here, you will be most welcome to visit any of the laboratories.

Finally, before handing over the microphone to Prof. Zifferero, I would like to have the honour of introducing the overseas delegates to the audience.

Thank you.

Appendix 3

SIXTH RCA WORKING GROUP MEETING

OPENING REMARKS

Professor Maurizio Zifferero
Deputy Director General
Head of the Department of Research and Isotopes
International Atomic Energy Agency
Vienna, Austria

Dr. Ramanna, Dr. Sundaram, Dr. Gopinath, Ambassador Singh, distinguished delegates and guests from RCA Member States, observers from Asian and Pacific countries, ladies and gentlemen.

It is a great honour and pleasure to address the 6th Working Group Meeting of RCA Member States in India, one of the most active supporters and participants of RCA.

I welcome all of you on behalf of the Director General of the International Atomic Energy Agency.

I would like at this time to express the appreciation of the Agency to the Government of India for hosting this meeting and compliment the staff of the Indian Atomic Energy Authority for the excellent arrangements.

The steady growth of RCA activities is requiring more and more coordination work. For this reason, as announced at the 12th Meeting of Representatives of RCA Member States, the Agency has decided to establish a post for this function at the Director level. In the past, RCA coordination was assigned, as you know, as a part-time activity to the Head of the Industrial Applications and Chemistry Section, Mr. Sueo Machi. I would like to take this opportunity to convey to Mr. Machi, who left the Agency shortly after our last meeting in Dhaka, our appreciation and gratitude for his untiring efforts to develop and promote RCA activities. The functions of coordinator have been taken over by Mr. Masatoshi Kobayashi, whose long experience in nuclear science and technology transfer will be of great benefit to our programmes.

The 1984 consolidated budget for RCA activities reached the level of US$2,454,559, which represents approximately 2% of the Agency's total consolidated budget.

Of this amount, a major portion, namely $1,621,059, relates to the UNDP Industrial Project. This includes the special contributions by the Governments of Australia and Japan and industries in the region. The amount of the budget earmarked for research and training activities in 1984 is US$833,500 to be funded from the Agency research programme budget and special contributions by donor RCA countries.

A comparison between the 1983 and 1984 budget shows a decrease in the UNDP project expenditures of approximately one million dollars. In fact, most of the equipment purchasing has been completed in 1983. At the same time, the budget for research and training activities for 1984 has practically doubled and is now approaching the one million US dollar mark.

Let me now briefly review the status of current activities and the prospects for the near future.

In all the ongoing projects, remarkable progress has been made, as is evident from the relevant project documents which will be discussed at this meeting.

The four projects on medical and biological applications of nuclear techniques, which were approved in 1983, have become operational in the course of the year. With the financial support of the Japanese Government, a research coordination meeting on cancer therapy was held in Kyoto, Japan in December 1983 and a consultants' meeting on nucleasr medicine was held recently in Vienna. An after-loading teletherapy apparatus for cervix cancer treatment, donated by the Government of Japan to the Agency, is now being transferred to Malaysia. The Australian Government has also indicated its intention to actively support RCA activities in the area of nuclear medicine and we gratefully acknowledge the offer by the Australian Government to host a training course on radio-immunoassay as announced at the October General Conference RCA/12 meeting.

The new project on "Basic science using research reactors" is being implemented through the financial support and the cooperation of the Government of India, and the first training workshop on "The use of microprocessors in research reactor utilization" was held at the Bhabha Atomic Research Centre, 30 January - 17 February 1984.

The project on "Food irradiation", which has been supported by the Government of Japan over three years (1980-1982), and was extended for another year in 1983, will be terminated this year. A survey mission has reviewed this programme in June 1983 and has confirmed the success of the Phase I project.

In the course of the Fifth RCA Working Group Meeting held in Dhaka last May, many countries expressed their interest in continuing the activity in food irradiation and to establish a Phase II project. Accordingly, the Agency has undertaken contacts with the Australian authorities to explore the possibility of financial support to this programme. The Australian Government has not yet formally announced its response but I am glad to report that prospects look favourable on this matter.

The UNDP Industrial Project has been steadily progressing in most of the sub-projects.

As you know, the Government of Australia had continued to provide funding for the coordinated research programme on "Isotope applications in hydrology and sedimentology" for many years which resulted in the establishment of hydrology laboratories in many participating countries. The financial contribution of the Government of Australia has now been shifted to the sub-project "Nucleonic control systems, mineral exploration, mining and processing" under the UNDP Industrial Project. The first training demonstration course under this sub-project on "On-stream analysis and control of mineral concentrators" was held in Australia and the Philippines.

The Government of Japan has continued its support and cooperation in several sub-projects of the UNDP Industrial Project, including radiation processing, non-destructive testing, nucleonic control systems, and maintenance of nuclear instruments.

The installation of a Co-60 irradiation facility for vulcanization of natural rubber latex was completed in Jakarta in September 1983, and a nucleonic control system for the steel industry was installed at the Bokaro Steel Plant in India. The first training courses have been carried out at these sites.

At the 12th Meeting of Representatives of RCA Member States, held on 12 October 1983 in Vienna, a draft plan for NDT Certification and Training was submitted and the conclusion will be compiled after receiving the comments of participating Member States.

Finally, the UNDP project office was officially opened in Jakarta on 1 July 1983. As from the same date, Mr. Sobhak Kasemsanta was appointed UNDP Project Co-ordinator.

The accession of the People's Republic of China to the International Atomic Energy Agency has been formalized and China is now an Agency Member State as from the first of January of this year. China has indicated keen interest in a number of RCA projects and I know that you join me in welcoming this interest and in recognizing the important role China could play in RCA in the future.

Ladies and gentlemen, distinguished delegates.

In concluding my remarks, I should like to note with satisfaction the steady growth of our activities, the increasing funding effort of donor countries, and the number of achievements since we met in Dhaka a year ago.

This success is the outcome of effective cooperation, governmental support and of the full commitment and dedication of all participants.

I wish you a successful meeting.

SIXTH RCA WORKING GROUP MEETING

INAUGURAL ADDRESS

Dr. R. Ramanna
Chairman
Atomic Energy Commission, India

Dr. Zifferero, distinguished delegates from the RCA countries, and colleagues:

To the words of welcome extended by Mr. Sundaram, Director of this Centre, I wish to add mine, both on behalf of the Atomic Energy Commission as well as on my own behalf.

It gives me particular happiness to welcome you all to this Centre here at Kalpakkam, for it is from here, on the East coast, that our trade and cultural connections with the East were established several centuries ago.

In fact, even as you entered the precincts of this Centre, you must have passed through the environs of Mahabalipuram, where there are exquisite examples of Indian temple architecture. The shore temple of Mahabalipuram was built some 1300 years ago and is perhaps the archetype after which some of the temples of South East Asia were fashioned.

I draw attention to these ancient reminders of our historic past with a purpose. While I invite you all to take advance of this occasion to visit these beautiful monuments all over the State, I would also like to express the hope that this meeting, for which we are all assembled here, would bring us together to seek common inspiration to achieve our respective national goals in the field of nuclear science and technology. I say this because there are so many problems, so many hindrances, so many intermediate steps that we all have to go through in bringing modern science and technology to meaningfully improve the quality of our lives that there is a compelling case for a common approach.

The Regional Cooperative Agreement (RCA) which was first signed in June 1972, with which I have been privileged to be personally associated from its very inception and in whose birth I can claim some credit, has undoubtedly been a success during the last twelve years. While we are all appreciative of the constructive role played by the Agency, I tend to believe that this success is to be attributed to the truly cooperative effort which all the participating Member States of the Region have put in to benefit from each other's experiences. This sharing of experience has resulted from pursuing common goals and at the same time recognizing a number of common problems. For instance, we all have identified the utilization of research reactors, the production, handling and application of radioisotopes, the use of radiation processing in preserving commodities of economic importance and the application of nuclear radiation in medicine, as some of the important areas in which nuclear science could be expected to have an immediate impact. Using research reactor utilization as a means, we have made a major effort in manpower training, bringing in RCA programmes to assist larger national efforts. Coordinated research programmes, research contracts, research coordination meetings, newsletters, etc. have sprung up under the aegis of RCA to our mutual benefit. All these have brought our young nuclear scientists and technologists together. We can proudly say that today we have a well-knit community of nuclear scientists in the Region.

I am, therefore, particularly happy to be here this morning to inaugurate this Sixth RCA Working Group meeting. As I can perhaps claim to be a "Charter Member" of the RCA, I would like (with your indulgence) to voice some thoughts on its future.

Where do we go from here? The atomic energy institutions in all our countries are now mature enough to interact with each other on more sophisticated topics and deal with specific technologies. I dare say, therefore, that there will be an increase in the scope and range of coordinated research activities, exchanges of equipment, of personnel at various levels and of information. This is all to our common good and I hope during these four days you will identify such programmes for immediate attention.

But let us remind ourselves that atomic energy programmes were embarked upon by various countries, to provide long-term solutions to growing energy needs. As we - and here I am referring primarily to those RCA countries, most of them like mine are called "developing" - industrialize and improve the living standards of our people, expectations will rise and great demands will be made in basic sectors of the economy, like energy. For example, in India our total installed generation capacity is expected to rise from the present 30,000 MWe to 100,000 MWe by the end of the century. To achieve this, a target of 10,000 MWe of nuclear power has been set. Similarly, some other countries have also drawn up plans for nuclear power.

Despite all that has been said in the wake of the global oil crises of the last decade, all of us realize that nuclear energy is the ultimate and only long-term answer to the energy problem. But let us not forget that fossil fuels will not last for more than fifty years. With the population levels that will prevail at that time, the inevitability of nuclear energy cannot be contested. Therefore, our national atomic energy efforts will have to gear themselves up for answering this call. I venture to suggest that we should use the RCA programmes to address ourselves to cooperative aspects of these questions also in the years to come.

We have to re-assess the role of atomic energy in the total energy scenario of the developing countries during the coming decades. A little reflection will convince most of us in the developing world that the answers and options in the advanced industrialized world are not always applicable here and wisdom lies in working out our own answers. In fact, there are many other aspects of nuclear power in which the options for the developing world are wholly different. Our power demands, grid sizes, technology assimilation rates and infrastructural support do not always permit adopting the state-of-the-art technology of the developed world. We have to choose deliberately the rate at which nuclear power technology can grow in our countries. I believe RCA activities can be brought in to play a role in identifying our commonality of circumstances and pursuing the similar objectives that lie ahead.

In this context, it appears to us that all the opposition to nuclear power on environmental grounds and the slowing down of power reactor construction programmes are temporary phenomena. If they are not, I suggest that it is unscientific to put off the problems learning to make nuclear power safe. In fact, it is my view that there is no industry which has paid as much attention from its very birth to safety as the nuclear power industry.

I am not entering into any controversy here, but I am bringing up this point only to emphasize that this is a technology we have to master and we in the developing world should not let up on our efforts.

The Reactor Research Centre here at Kalpakkam is, for these reasons, a particularly appropriate venue for the RCA meeting. It was my desire to bring you all here to see for yourselves how we are pursuing the objective of finding our own path to the nuclear power generation problems. Here you will see, adjacent to this research centre, the fifth and latest of our power reactors to go on stream; the first Unit of the Madras Atomic Power Station. It is a 235 MWe, natural uranium, heavy water reactor, which is almost entirely indigenously built. It has been steadily supplying power to the Southern grid for a few months now. We have decided to build many such reactors of this type for some more years, even though power generation technology in the world would tend to favour larger systems. This is because stations of this size are more appropriate to our industry and to our grid size.

Similarly, at this Research Centre, you will see the Fast Breeder Test Reactor (FBTR) which will shortly go into operation and you will hear about our plans for a Prototype Fast Breeder Reactor (PFBR) which is a 500 MWe system. One of the main objectives of our breeder reactors is to convert thorium, a proposition few other countries in the world are willing to consider. But here again, we are fully convinced that, though the problems are tough, solutions have to be found because our thorium reserves hold out the greatest hope for our energy profiles of the future. It is my hope that, while at Kalpakkam, you will see that we are working hard on the problems we have set for ourselves.

With these words, I have great pleasure in inaugurating this Sixth RCA Working Group meeting and hope that your deliberations are useful and you will carry happy memories of your visit to India.

Appendix 5

SIXTH RCA WORKING GROUP MEETING

VOTE OF THANKS

D.V. Gopinath

Dr. Ramanna, Ambassador Singh, Professor Zifferero, distinguished delegates from overseas, my colleagues from Bombay and Kalpakkam.

On behalf of the local organizing committee, I would like to express our thanks to the International Atomic Energy Agency for accepting our invitation to have this meeting in India and the Department of Atomic Energy of India for choosing Kalpakkam as the venue for the meeting. We very much value meetings and discussions aimed at increasing the international collaborative effort and it is a pleasure to have you with us today. In spite of his very busy schedule, Dr. Ramanna, Chairman of the Atomic Energy Commission, has kindly consented to be with us today and to inaugurate the meeting and I would like to express our gratitude to Dr. Ramanna. It is a pleasure to have Ambassador Shri S.K. Singh with us today and I would like to thank him also. Our special thanks are due to Professor Zifferero, Deputy Director General, IAEA, and Dr. Kobayashi, RCA Coordinator, for being present today. As Shri C.V. Sundaram mentioned earlier, for many of the delegates the time available for planning to attend this meeting might have been rather short and this could have posed several problems. That you have been able to be with us today in spite of these difficulties makes us very happy and we are grateful to you for this. I would like to express my gratitude to my colleagues from Bombay for being present.

During the course of the preparations for this meeting we have received very valuable guidance from all the members of the steering committee, and particularly from Shri C.V. Sundaram, Shri M.K.P. Rao, and Shri P.K. Bhatnagar. I would like to record our sincere gratitude to the management and staff of the Reactor Research Centre, Madras Atomic Power Project, General Services Organization and Centralized Waste Management Facility for extending their full cooperation and providing all the help we sought.

We have tried our best to make your stay useful and enjoyable. In spite of our best efforts, it is likely that there could be some deficiencies. I would request you to kindly bear with the possible shortcomings. I wish you all a happy meeting and a pleasant stay at Kalpakkam.

Thank you.

Appendix 6

SIXTH RCA WORKING GROUP MEETING

STATUS REPORT OF COOPERATIVE RESEARCH PROJECTS 1983/1984

OUTLINE

The 12th Meeting of Representatives of RCA Member States was held at the Hofburg, Vienna, on 12 October 1983, chaired by Mr. K.G. Dharmawardena of Sri Lanka. The report of the 5th RCA Working Group meeting was accepted to serve as the Report and Recommendations of RCA/12.

The 1984 RCA budget is estimated to be US$2,454,559. The budget for research projects is US$833,500 and that for the UNDP Industrial Project is US$1,621,059. Sources arte the IAEA regular budget, UNDP dunds and special contributions from RCA countries.

The four projects on Medical and Biological Applications of Nuclear Techniques, approved by the Director General of IAEA in 1983, have been implemented.

The project on Food Irradiation was extended up to August 1984. Interest in the Phase II project has been manifested by participating countries, which was clarified by a Survey Mission dispatched in June 1983.

The new permanent UNDP Project Office was opened in Jakarta on 1 July 1983, and the interim office in Tokyo was closed. After the retirement of Mr. E.E. Fowler, the former Project Director and UNDP Chief Technical Advisor, Mr. S.P. Kasemsanta, former Secretary General of OAEP, Thailand, was nominated as UNPD Project Coordinator in July 1983.

A 300 KCi Co-60 irradiation facility for the natural rubber latex vulcanization programme was constructed in Jakarta, at the Centre for Application of Isotopes and Radiations (CAIR), in September 1983.

A draft of a certifiction scheme for NDT specialists was presented at RCA/12 and will be adopted after receiving the comments of participating countries.

RCA/13 is scheduled to take place during the 1984 IAEA General Conference in Vienna.

USE OF INDUCED MUTATIONS FOR IMPROVEMENT OF GRAIN LEGUME PRODUCTION

The 4th research coordination meeting was held at NIAB, Faisalabad, Pakistan, 5-9 March 1984. The participants of the programme have made good progress in developing new, more productive plant types of various pulse species. The coordinated research programme was scheduled to phase out in 1984; however, it is suggested to extend the duration of the programme to 1986.

FOOD IRRADIATION

Upon the recommendation of the meeting of the RPFI Project Committee in Bangkok in 1982, the Agency circulated the text of an agreement to extend the project for one year to all governments party to the RPFI on July 15, 1983, and the Governments already notified the Agency of their acceptance. The extension agreement entered into force on 25 August 1983, and will continue until 27 August 1984.

As a follow-up to the recommendations of the 3rd RPFI Project Committee, the Agency dispatched a team of 5 experts to evaluate the progress of work in Indonesia, the Philippines, Thailand and Bangladesh. According to the report of this Mission, the food irradiation technology in most RPFI countries has reached the stage where it can be transferred to industries. The Mission recommended strongly that the Agency should provide financial support to the Phase II project, either from its own resources or from donor governments.

The Agency has approached the Government of Japan regarding financial support of the Phase II project. At RCA/12, the Japanese delegation expressed the view that provision of funds would be difficult in 1984, and that they would prefer to provide "in kind" contributions.

NUCLEAR TECHNIQUES TO IMPROVE DOMESTIC BUFFALO PRODUCTION

The final research coordination meeting was held in Manila 30 January - 3 February 1984. The work on reproduction has characterized the reproductive capacity of different breeds of buffalo in different countries. The use of radioimmunoassay techniques has been identified as a suitable tool for monitoring the reproductive status. The isotope-based studies on nutrition and pathogenesis have also progressed. The second phase of the project will start in 1984 for another five years.

STERILIZATION OF BIOLOGICAL TISSUE GRAFTS

The coordinated research programme on "Radiation sterilization practices for medical supplies, carried out from 1978, was phased out in 1983 upon successful attainment of the objectives. The programme helped to prepare a draft outline of the national Code of Practice. The draft is due for updating in 1986. On the occasion of the IAEA/WHO Seminar on Tissue Banking, to be held in Manila, 7-11 May 1984, the details of the new coordinated research programme will be drafted and submitted to IAEA for consideration.

HEALTH-RELATED ENVIRONMENTAL RESEARCH

The 3rd and final research coordination meeting was held at the National University of Malaysia, Kuala Lumpur, 1-3 November 1983. All participants agreed that the research programme as a whole can be regarded as a success. The present programme will be phased out by the end of March 1984, and the detailed proposals for a new programme, either within the framework of RCA or as a part of a global coordinated research programme, will be prepared in the course of this year with a view to implementation in 1985. To improve the analytical capabilities of laboratories in RCA countries, a training course is planned for 1985.

MAINTENANCE OF NUCLEAR INSTRUMENTS

The project now has 10 active participants and the work on power conditioning has now entered its final stage. A second train-the-trainers workshop will be held in April/May in Kuala Lumpur and the research coordination meeting was held at BARC in December 1983. The 1984 programme will concentrate on air conditioning, training, maintenance management and spare parts supply.

BASIC SCIENCE USING RESEARCH REACTORS

A three-week workshop on "The use of microprocessors in research reactor utilization" was held at the Bhabha Atomic Research Centre, Bombay, 30 January - 17 February 1984, with the financial support of the Government of India. The workshop was developed by scientists of BARC in cooperation with IAEA staff. Applications from 14 scientists from 8 RCA countries were received.

ISOTOPE APPLICATIONS IN HYDROLOGY AND SEDIMENTOLOGY

The programme includes field studies in Indonesia, the Republic of Korea, Malaysia and Thailand. As was announced at the last Working Group meeting in Dhaka, the cash contribution of the Australian Government to this programme has been shifted to a sub-project of the UNDP Industrial Project, so that the hydrology programme will be implemented with reduced funding by IAEA in 1984.

SEMI-DWARF MUTANTS FOR RICE IMPROVEMENT

The first research coordination meeting was held at IRRI, Los Ranos, the Philippines, 24-28 October 1983, and was dedicated to the problems of agronomic evaluation of semi-dwarf mutants of rice obtained in participating laboratories. The participants obtained a large number of new semi-dwarf mutants which must be evaluated in field conditions. Results of these experiments will be discussed during the next research coordination meeting which will be held in 1985.

IMPROVEMENT OF CANCER THERAPY

After the approval of this coordinated research programme in April 1982, the first coordination meeting was held in Japan in December 1983, and included 9 participants, 2 consultants and 27 observers. The next coordination meeting, which was proposed to be held in India in 1984, will be postponed to 1985 due to financial considerations and also to allow for sufficient time for further research.

NUCLEAR MEDICINE FOR LIVER AND THYROID DISEASES

A specialists meeting was scheduled for 20 February 1984 to review medical requirements in the region for radionuclide investigations, and to propose a coordinated research programme and training. This meeting had to be postponed due to financial considerations. The Agency has requested the nomination of counterparts in the respective participating countries and has received 13 names.

At RCA/12, the Representative of Australia officially announced that his Government would host a training course on radioimmunoassay.

NUCLEAR TECHNIQUES FOR TROPICAL PARASITIC DISEASES

This programme was started in October 1983 and, by the end of the year, included 8 research contracts. Applications from Indonesia and the Republic of Korea are expected. The work plan began in December 1983 and includes the collection of serum and urine specimens from patients with malaria or filariasis, and all the institutes involved are expected to complete the assay of the specimens by September 1984.

DEVELOPMENT OF 99m-Tc GENERATOR SYSTEMS

The goal of this programme is the development of an appropriate technology for the preparation of 99m-Tc generator systems using low specific activity Mo-99 produced in low power research reactors.

Letters were sent to all Member States currently in possession of a nuclear research reactor, inviting them to present formal proposals for participation in the programme. There are currently five participants, and research contracts with scientists from Bangladesh and the Republic of Korea are expected to be signed in the near future.

CODEX STAN 106-1983

CODEX GENERAL STANDARD FOR IRRADIATED FOODS (*)
(World-wide Standard)

1. SCOPE

This standard applies to foods processed by irradiation. It does not apply to foods exposed to doses imparted by measuring instruments used for inspection purposes.

2. GENERAL REQUIREMENTS FOR THE PROCESS

2.1. Radiation Sources

The following types of ionizing radiation may be used:

(a) Gamma rays from the radionuclides ^{60}Co or ^{137}Cs;

(b) X-rays generated from machine sources operated at or below an energy level of 5 MeV.

(c) Electrons generated from machine sources operated at or below an energy level of 10 MeV.

2.2. Absorbed Dose

The overall average dose absorbed by a food subjected to radiation processing should not exceed 10 kGy (1) (2).

2.3. Facilities and Control of the Process

2.3.1. Radiation treatment of foods shall be carried out in facilities licensed and registered for this purpose by the competent national authority.

2.3.2. The facilities shall be designed to meet the requirements of safety, efficacy and good hygienic practices of food processing.

2.3.3. The facilities shall be staffed by adequate, trained and competent personnel.

2.3.4. Control of the process within the facility shall include the keeping of adequate records including quantitative dosimetry.

(*) Revised version of the Recommended International General Standard for Irradiated Foods (CAC/RS 106-1979).

(1) and (2) See notes on page 4.

2.3.5. Premises and records shall be open to inspection by appropriate national authorities.

2.3.6. Control should be carried out in accordance with the Recommended International Code of Practice for the Operation of Radiation Facilities used for the Treatment of Foods (CAC/RCP 19-1979, Rev. 1).

3. HYGIENE OF IRRADIATED FOODS

3.1. The food should comply with the provisions of the Recommended International Code of Practice - General Principles of Food Hygiene (Ref. No. CAC/RCP 1-1969, Rev. 1, 1979) and, where appropriate, with the Recommended International Code of Hygienic Practice of the Codex Alimentarius relative to a particular food.

3.2. Any relevant national public health requirement affecting microbiological safety and nutritional adequacy applicable in the country in which the food is sold should be observed.

4. TECHNOLOGICAL REQUIREMENTS

4.1. Conditions for Irradiation

The irradiation of food is justified only when it fulfils a technological need or where it serves a food hygiene purpose (3) and should not be used as a substitute for good manufacturing practices.

4.2. Food Quality and Packaging Requirements

The doses applied shall be commensurate with the technological and public health purposes to be achieved and shall be in accordance with good radiation processing practice. Foods to be irradiated and their packaging materials shall be of suitable quality, acceptable hygienic condition and appropriate for this purpose and shall be handled, before and after irradiation, according to good manufacturing practices taking into account the particular requirements of the technology of the process.

(3) See note on page 4.

5.1 RE-IRRADIATION

5.1. Except for foods with low moisture content (cereals, pulses, dehydrated foods and other such commodities) irradiated for the purpose of controlling insect reinfestation, foods irradiated in accordance with sections 2 and 4 of this standard shall not be re-irradiated.

5.2. For the purpose of this standard food is not considered as having been re-irradiated when: (a) the food prepared from materials which have been irradiated at low dose levels e.g. about 1 kGy, is irradiated for another technological purpose; (b) the food, containing less than 5 % of irradiated ingredient, is irradiated, or when (c) the full dose of ionizing radiation required to achieve the desired effect is applied to the food in more than one instalment as part of processing for a specific technological purpose.

5.3. The cumulative overall average dose absorbed should not exceed 10 kGy as a result of re-irradiation.

6. LABELLING

6.1. Inventory Control

For irradiated foods, whether prepackaged or not, the relevant shipping documents shall give appropriate information to identify the registered facility which has irradiated the food, the date(s) of treatment and lot identification.

6.2. Prepackaged foods intended for direct consumption

The labelling of prepackaged irradiated foods shall be in accordance with the relevant provisions of the Codex General Standard for the Labelling of Prepackaged Foods (4).

6.3. Foods in bulk containers

The declaration of the fact of irradiation shall be made clear on the relevant shipping documents.

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(4) See note on page 4.

(1) For measurement and calculation of overall average dose absorbed see Annex A of the Recommended International Code of Practice for the Operation of Radiation Facilities used for Treatment of Foods (CAC/RCP 19-1979, Rev. 1).

(2) The wholesomeness of foods, irradiated so as to have absorbed an overall average dose of up to 10 kGy, is not impaired. In this context the term "wholesomeness" refers to safety for consumption of irradiated foods from the toxicological point of view. The irradiation of foods up to an overall average dose of 10 kGy introduces no special nutritional or microbiological problems (Wholesomeness of Irradiated Foods, Report of a Joint FAO/IAEA/WHO Expert Committee, Technical Report Series 659, WHO, Geneva, 1981).

(3) The utility of the irradiation process has been demonstrated for a number of food items listed in Annex B to the Recommended International Code of Practice for the Operation of Radiation Facilities used for the Treatment of Foods.

(4) Under revision by the Codex Committee on Food Labelling.

RECOMMENDED INTERNATIONAL CODE OF PRACTICE FOR THE OPERATION OF IRRADIATION FACILITIES USED FOR THE TREATMENT OF FOODS (*)

1. INTRODUCTION

This code refers to the operation of irradiation facilities based on the use of either a radionuclide source (^{60}Co or ^{137}Cs) or X-rays and electrons generated from machine sources. The irradiation facility may be of two designs, either "continuous" or "batch" type. Control of the food irradiation process in all types of facility involves the use of accepted methods of measuring the absorbed radiation dose and of the monitoring of the physical parameters of the process. The operation of these facilities for the irradiation of food must comply with the Codex recommendations on food hygiene.

2. IRRADIATION PLANTS

2.1. Parameters

For all types of facility the doses absorbed by the product depend on the radiation parameter, the dwell time or the transportation speed of the product, and the bulk density of the material to be irradiated. Source-product geometry, especially distance of the product from the source and measures to increase the efficiency of radiation utilization, will influence the absorbed dose and the homogeneity of dose distribution.

2.1.1. Radionuclide sources

Radionuclides used for food irradiation emit photons of characteristic energies. The statement of the source material completely determines the penetration of the emitted radiation. The source activity is measured in Becquerel (Bq) and should be stated by the supplying organisation. The actual activity of the source (as well as any return or replenishment of radionuclide material) shall be recorded. The recorded activity should take into account the natural decay rate of the source and should be

(*) Revised version of the Recommended International Code of Practice for the Operation of Radiation Facilities used for the Treatment of Foods (CAC/RCP 19-1979).

accompanied by a record of the date of measurement or recalculation. Radionuclide irradiators will usually have a well separated and shielded depository for the source elements and a treatment area which can be entered when the source is in the safe position. There should be a positive indication of the correct operational and of the correct safe position of the source which should be interlocked with the product movement system.

2.1.2. Machine sources

A beam of electrons generated by a suitable accelerator, or after being converted to X-rays, can be used. The penetration of the radiation is governed by the energy of the electrons. Average beam power shall be adequately recorded. There should be a positive indication of the correct setting of all machine parameters which should be interlocked with the product movement system. Usually a beam scanner or a scattering device (e.g. the converting target) is incorporated in a machine source to obtain an even distribution of the radiation over the surface of the product. The product movement, the width and speed of the scan and the beam pulse frequency (if applicable) should be adjusted to ensure a uniform surface dose.

2.2. Dosimetry and Process Control

Prior to the irradiation of any foodstuff certain dosimetry measurements (1) should be made, which demonstrate that the process will satisfy the regulatory requirements. Various techniques for dosimetry pertinent to radionuclide and machine sources are available for measuring absorbed dose in a quantitative manner (2).

Dosimetry commissioning measurements should be made for each new food, irradiation process and whenever modifications are made to source strength or type and to the source product geometry.

Routine dosimetry should be made during operation and records kept of such measurement. In addition, regular measurements of facility parameters governing the process,

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(1) See Annex A to this Code.
(2) Detailed in the Manual of Food Irradiation Dosimetry, IAEA, Vienna, 1977, Technical Report Series No. 178.

such as transportation speed, dwell time, source exposure time, machine beam parameters, can be made during the facility operation. The records of these measurements can be used as supporting evidence that the process satisfies the regulatory requirements.

3. GOOD RADIATION PROCESSING PRACTICE

Facility design should attempt to optimalize the dose uniformity ratio, to ensure appropriate dose rates and, where necessary, to permit temperature control during irradiation (e.g. for the treatment of frozen food) and also control of the atmosphere. It is also often necessary to minimize mechanical damage to the product during transportation irradiation and storage, and desirable to ensure the maximum efficiency in the use of the irradiator. Where the food to be irradiated is subject to special standards for hygiene or temperature control, the facility must permit compliance with these standards.

4. PRODUCT AND INVENTORY CONTROL

4.1. The incoming product should be physically separated from the outgoing irradiated products.

4.2. Where appropriate, a visual colour change radiation indicator should be affixed to each product pack for ready identification of irradiated and non-irradiated products.

4.3. Records should be kept in the facility record book which show the nature and kind of the product being treated, its identifying marks if packed or, if not, the shipping details, its bulk density, the type of source or electron machine, the dosimetry, the dosimeters used and details of their calibration, and the date of treatment.

4.4. All products shall be handled, before and after irradiation, according to accepted good manufacturing practices taking into account the particular requirements of the technology of the process (3). Suitable facilities for refrigerated storage may be required.

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(3) See Annex B to this Code.

ANNEX A

DOSIMETRY

1. The overall average absorbed dose

It can be assumed for the purpose of the determination of the wholesomeness of food treated with an overall average dose of 10 kGy or less, that all radiation chemical effects in that particular dose range are proportional to dose.

The overall average dose, $\bar{D}$, is defined by the following integral over the total volume of the goods

$$\bar{D} \div \frac{1}{M} \int \rho \, (x, y, z) \cdot d \, (x, y. z) \cdot dV$$

where

- M = the total mass of the treated sample
- ρ = the local density at the point (x, y, z)
- d = the local absorbed dose at the point (x, y, z)
- dV = dx dy dz the infinitesimal volume element which in real cases is represented by the volume fractions.

The overall average absorbed dose can be determined directly for homogeneous products or for bulk goods of homogeneous bulk density by distributing an adequate number of dose meters strategically and at random throughout the volume of the goods. From the dose distribution determined in this manner an average can be calculated which is the overall average absorbed dose.

If the shape of the dose distribution curve through the product is well determined the positions of minimum and maximum dose are known. Measurements of the distribution of dose in these two positions in a series of samples of the product can be used to give an estimate of the overall average dose. In some cases the mean value of the average values of the minimum ($\bar{D}min$) and maximum ($\bar{D}max$) dose will be a good estimate of the overall average dose.
i.e. in these cases

$$\text{overall average dose} \approx \frac{\bar{D}max + \bar{D}min}{2}$$

2. Effective and limiting dose values

Some effective treatment e.g. the elimination of harmful microorganisms, or a particular shelflife extension, or a disinfestation requires a minimum absorbed dose. For other applications too high an absorbed dose may cause undesirable effects or an impairment of the quality of the product.

The design of the facility and the operational parameters have to take into account minimum and maximum dose values required by the process. In some low dose applications it will be possible within the terms of section 3 on Good Radiation Processing Practice to allow a ratio of maximum to minimum dose of greater than 3.

With regards to the maximum dose value under acceptable wholesomeness considerations and because of the statistical distribution of the dose a mass fraction of product of at least 97.5 % should receive an absorbed dose of less than 15 kGy when the overall average dose is 10 kGy.

3. Routine Dosimetry

Measurements of the dose in a reference position can be made occasionally throughout the process. The association between the dose in the reference position and the overall average dose must be known. These measurements should be used to ensure the correct operation of the process. A recognized and calibrated system of dosimetry should be used.

A complete record of all dosimetry measurements including calibration must be kept.

4. Process Control

In the case of a continuous radionuclide facility it will be possible to make automatically a record of transportation speed or dwell time together with indications of source and product positioning. These measurements can be used to provide a continuous control of the process in support of routine dosimetry measurements.

In a batch operated radionuclide facility automatic recording of source exposure time can be made and a record of product movement and placement can be kept to provide a control of the process in support of routine dosimetry measurements.

In a machine facility a continuous record of beam parameters, e.g. voltage, current, scan speed, scan width, pulse repetition and a record of transportation speed through the beam can be used to provide a continuous control of the process in support of routine dosimetry measurements.

ANNEX B

EXAMPLES OF TECHNOLOGICAL CONDITIONS FOR THE IRRADIATION OF SOME INDIVIDUAL FOOD ITEMS SPECIFICALLY EXAMINED BY THE JOINT FAO/IAEA/WHO EXPERT COMMITTEE

This information is taken from the Reports of the Joint FAO/IAEA/WHO Expert Committees on Food Irradiation (WHO Technical Report Series, 604, 1977 and 659, 1981) and illustrates the utility of the irradiation process. It also describes the technological conditions for achieving the purpose of the irradiation process safely and economically.

1. CHICKEN (Gallus domesticus)

1.1. Purposes of the Process

The purposes of irradiating chicken are:

(a) to prolong storage life
and/or
(b) to reduce the number of certain pathogenic micro-organisms, such as Salmonella from eviscerated chicken.

1.2. Specific Requirements

Average dose: for (a) and (b), up to 7 kGy

2. COCOA BEANS (Theobroma cacao)

2.1. Purposes of the Process

The purposes of irradiating cocoa beans are:

(a) to control insect infestation in storage
(b) to reduce microbial load of fermented beans with or without heat treatment.

2.2. Specific Requirements

2.2.1. Average dose: for (a) up to 1 kGy
for (b) up to 5 kGy

2.2.2. Prevention of Reinfestation: Cocoa beans whether prepackaged or handled in bulk, should be stored as far as possible, under such conditions as will prevent reinfestation and microbial recontamination and spoilage.

3. DATES (Phoenix dactylifera)

3.1. Purpose of the Process.
The purpose of irradiating prepackaged dried dates is to control insect infestation during storage.

3.2. Specific Requirements

3.2.1. Average dose: up to 1 kGy

3.2.2. Prevention of Reinfestation: Prepackaged dried dates should be stored under such conditions as will prevent reinfestation.

4. MANGOES (Mangifera indica)

4.1. Purposes of the Process
The purposes of irradiating mangoes are:
(a) to control insect infestation
(b) to improve keeping quality by delaying ripening
(c) to reduce microbial load by combining irradiation and heat treatment.

4.2. Specific Requirements
Average dose: up to 1 kGy

5. ONIONS (Allium cepa)

5.1. Purpose of the Process
The purpose of irradiating onions is to inhibit sprouting during storage.

5.2. Specific Requirement
Average dose: up to 0.15 kGy

6. PAPAYA (Carica papaya L.)

6.1. Purpose of the Process
The purpose of irradiating papaya is to control insect infestation and to improve its keeping quality by delaying ripening.

6.2. Specific Requirements

6.2.1. Average dose: up to 1 kGy

6.2.2. Source of Radiation: The source of radiation should be such as will provide adequate penetration.

7. POTATOES (Solanum tuberosum L.)

7.1. Purpose of the Process
The purpose of irradiating potatoes is to inhibit sprouting during storage.

7.2. Specific Requirement
Average dose: up to 0.15 kGy

8. PULSES

8.1. Purpose of the Process
The purpose of irradiating pulses is to control insect infestation in storage.

8.2. Specific Requirement
Average dose: up to 1 kGy

9. RICE (Oryza species)

9.1. Purpose of the Process
The purpose of irradiating rice is to control insect infestation in storage.

9.2. Specific Requirements

9.2.1. Average dose: up to 1 kGy

9.2.2. Prevention of Reinfestation: Rice, whether prepackaged or handled in bulk, should be stored as far as possible, under such conditions as will prevent reinfestation.

10. SPICES AND CONDIMENTS, DEHYDRATED ONIONS, ONION POWDER

10.1. Purposes of the Process

The purposes of irradiating spices, condiments, dehydrated onions and onion powder are:

(a) to control insect infestation
(b) to reduce microbial load
(c) to reduce the number of pathogenic microorganisms.

10.2. Specific Requirement

Average dose: for (a) up to 1 kGy
for (b) and (c) up to 10 kGy.

11. STRAWBERRY (*Fragaria* species)

11.1. Purpose of the Process

The purpose of irradiating fresh strawberries is to prolong the storage life by partial elimination of spoilage organisms.

11.2. Specific Requirement

Average dose: up to 3 kGy

12. TELEOST FISH AND FISH PRODUCTS

12.1. Purposes of the Process

The purposes of irradiating teleost fish and fish products are:

(a) to control insect infestation of dried fish during storage and marketing
(b) to reduce microbial load of the packaged or unpackaged fish and fish products
(c) to reduce the number of certain pathogenic micro-organisms in packaged or unpackaged fish and fish products.

12.2. Specific Requirements

12.2.1. Average dose: for (a) up to 1 kGy
for (b) and (c) up to 2.2 kGy

12.2.2. Temperature Requirement: During irradiation and storage the fish and fish products referred to in (b) and (c) should be kept at the temperature of melting ice.

13. WHEAT AND GROUND WHEAT PRODUCTS (Triticum species)

13.1. Purpose of the Process
The purpose of irradiating wheat and ground wheat products is to control insect infestation in the stored product.

13.2. Specific Requirements

13.2.1. Average dose: up to 1 kGy

13.2.2. Prevention of Reinfestation: These products, whether prepackaged or handled in bulk, should be stored as far as possible under such conditions as will prevent reinfestation.

REPORT ON THE IAEA-RCA WORKSHOP ON THE USE OF MICROPROCESSORS IN RESEARCH REACTOR UTILIZATION

BHABHA ATOMIC RESEARCH CENTRE
January 30 - February 17, 1984

The workshop was attended by nine participants from RCA countries: Indonesia, the Republic of Korea, Malaysia, Philippines, Thailand, and Sri Lanka, as well as one participant from the IAEA Laboratory at Seibersdorf.

The schedule of the workshop included:

- Two lectures every morning.

The topics dealt with can be classified into two categories:

a) Basics of microprocessors and microcomputers: Basic digital electronics, computer organization, introduction to microprocessors, memories, study of Intel 8085, single board microcomputers, ADC/DAC, serial and parallel communications, interrupt systems, DMA communications, I/O devices, bus structures, overview of different types of microprocessors, machine/assembly language, higher level languages and aids.

b) Application of microcomputers: In neutron/X-ray scattering, in Mössbauer, XRF and gamma ray spectroscopy; for energy dispersive X-ray spectroscopy; in chemistry; in pulse height analysis and multichannel systems; for general nuclear application and personal computers.

- Practical experiments on six afternoons using 8085 kits. These experiments consisted of:

Introduction to components, probes, measuring instruments; study of an 8085 kit; study of I/O lines controls, reading the switches; sequential scanning; familiarization of a DAC; study of ADC; interfacing DAC and ADC to the kit; generation of various wave forms, ramps, etc. for control; software implementation.

- Demonstration experiments on other afternoons at the BARC Training School. These experiments were:

Observation of bus activity of 8085 using logic state analyser; study of 8253 timer chip; pulse height analysis using personal computer ZX-81; pulse heights analysis using personal computer SINCLAIR and a nuclear 12 bit ADC; word processor on HCL system II; microdevelopment system; use of arithmetic processors; x-y positioning by use of stopper motors through a microprocessor kit.

- A display of 14 microprocessor - based instruments developed at BARC. These instruments were:
1k multichannel analyser (DAPS-80); automatic liquid scintillation counting system; energy dispersive X-ray diffraction system; CPM/DBM system; impedance plythismograph; area radiation monitoring system; Mössbauer spetrcometer I; radioimmunoassay counter; portal monitor; private automatic

branch exchange; Mössbauer spectrometer II; master slave clock system; LSI-11 based pulse height acquisition and processing system;

- experimental equipment using microsystems; triple axis neutron spectrometer with Sc-MP based control system; Mossbauer system using 8080 microprocessor; activation analysis using 8085 processor.

- a visit to National Software Development Centre at Tata Institute of Fundamental Research and a visit to the Santacruz Electronics Export Promotion Zone at Andheri, Bombay.

The technical content of the Workshop was designed to familiarise the experimentalists with the basics of Microprocessors, appraise them of the availability of various associated chips available and discuss the logic of configuring them into a system. The emphasis was also to help the participants to acquaint themselves with microprocessor based systems to aid in on-line control and automation of experiments, on-line computation of various parameters and on-line processing of data wherever applicable.

The programme, with a tight schedule of lectures and practical sessions, found good response from the participants. They evinced keen interest to benefit from the course by working on the kits during late evenings and on Sundays at the Training School Hostel where they were all housed together. Two kits with instruction manuals, were made available for this purpose. About 25 technical books dealing with microprocessors were also made available at the hostel for reference purposes. Several lecturers and instructors used to have discussions with the participants in the evenings at the Hostel.

A feed-back session was organised in the middle of the course to elicit opinions from the participants as well as to judge the level of comprehension of the more advanced aspects. This helped in a slight readjustment to aid more effective communication. In particular, the lectures dealing with applications were oriented to give the method of attack that the designers chose in designing a specific microcomputer to suit the specifications and objectives of the user. Similarly, a set of layouts were specially prepared to show the details of interconnecting INTEL 8085 to other IC chips for I/o operations etc.

The participants felt that if the kits along with instruction manuals were given to them as part of Workshop material it would go a long way in consolidating the technical aspects they learnt at the Workshop. The cost of the kits along with mounted components and power supplies would come to about $9.500 for ten participants. If the IAEA provides financial support to this extent the kits can be sent to the participants from Bombay. Along with the course material, a copy of an excellent book on microprocessors by A.P. Mathur was given to each participant. A few participants bought some more books available for furthering their studies. The participants also opined that the course should have included fabrication of the kit itself as then they would have learnt all aspects from the scratch. The organising committee had discussed this aspect earlier but felt that fabrication of the kits by the participants would have involved at least another two weeks of practical work as then one would have had to provide training even in aspects like soldering, preparation of layout and so on. In the opinion of the organising committee such an exercise was outside the scope of the Workshop.

About 40 scientific and technical staff were involved in giving the academic support to the Workshop, in terms of course organisers, lecturers and instructors. Every practical course had each participant assisted by an instructor and the overall supervision of two or three course organisers. This high instructor-to-participant ratio was very necessary to ensure that each of the participant is guided through the practicals taking into account the previous background and experience of the participant. In the case of a few participants, who had prior familiarity, a few exercises of an advanced nature were also set up to give them the benefit of advanced expertise available at BARC.

The lecturers and instructors were drawn from about six Divisions of BARC (Nuclear, Neutron, Electronics, Computer, Training and Analytical Chemistry Divisions) and the Workshop was truly a multidisciplinary user-oriented one. It is our understanding that the aims and objectives of the course were amply fulfilled and the participants felt adequately satisfied at the high academic and technical level maintained throughout the Workshop.

Appendix 9

UNITED NATIONS DEVELOPMENT PROGRAMME

INTERNATIONAL ATOMIC ENERGY AGENCY

OFFICE OF THE PROJECT CO – ORDINATOR
c/o. CAIR BATAN
JL. CINERE PASAR JUMAT
PO. BOX 2/KBY. LAMA
JAKARTA SELATAN
INDONESIA

TELEPHONE : 761607
TELEX : 47113 IAEARCA IA
CABLE : JUMATOM JKT.

RAS/79/061 1984-03-09

Dear National Counterpart
National Co-ordinator
Training Course Director

I am enclosing herewith a Table of Project Work Plan for 1984, dated February 84 (Attachment 1) and a Time Table for the preparation of an Interim Report on Mid-Term Project Review (Attachment 2).

In this connection, I would like to take this opportunity to seek your kind co-operation as follows.

A. Project Evaluation and Interim Report on Mid-term Project Review

The Agency has agreed to an early initiation of certain steps in the process of Project Evaluation. One of the steps now being taken is, as you have already been informed, the engagement of Mr. E.E. Fowler, the former CTA and Project Director, to conduct Marketing Studies and make arrangements to convene Executive Management Seminars. In this connection, Mr. Fowler will maintain direct contact with you and keep me informed on the progress.

Concurrently, I am working jointly with the Senior Board of Advisors (SBA) to prepare an Interim Report on Mid-term Project Review, of which a working timetable is given in Attachment 2. As indicated in the Project Work Plan for 1984, I intend to finish drafting the Interim Report by August 1984 (Item 8.1 of the Work Plan) and submit the draft to the SBA in September. The Interim Report shall be then finalized in the Fifth Meeting of the SBA, planned for December 1984 (Item 12.1 of the Work Plan).

Enclosure

This Interim Report on Mid-term Project Review is a very important tool in the event that the Member States may wish to move for an extention of the present Project beyond December 1986, or wish to initiate a new project of the same nature but covering new areas of applications. In order to keep up with our working time table for the preparation of this Interim Report, I would need the help of all Project National Counterparts/ Co-ordinators (NCp) as indicated in para. 1 of the Time Table.

In this connection, I would need by mid-May 1984 comments and evaluation from the NCps on the past performance in implementing the various Sub-Projects. These comments should include, inter alia, factors (both from the Agency side and the Government side) which contribute to the progress of an individual Sub-Project or act as constraints impeding it; how succesful a training programme is in respect of the number of trained personnel, duration and quality of the course, how well trained participants in a country can utilize the knowledge gained and known impacts to industrial technology transfer; known new industrial investments in the areas covered by the Sub-Projects; etc.

If, for any reason, you are not able or not in-clined to make comments on all the Sub-Projects, I should be grateful to have your view atleast on the Sub-Project(s) or sub-area(s) that your Government serves as a host of the related activities, e.g. hosting the respective training-demonstration or providing experts for project development or for designing a pilot plant.

B. Plan for Regional Training and Certification of NDT Practices

This Plan was formally presented to the representatives of the RCA Governments at the RCA-12 Meeting held on 12 October 1983 in Vienna at the Hofburg. At this meeting, it has been agreed that formal comments and advices from the Governments on the proposed Plan shall be received by the Agency not later than 15 April 1984.

On the Agency side, a follow-up action on the proposal was taken as indicated in DDG Velez's letter RAS/79/061 of 14 December 1983, which was addressed to the respective Mission in Vienna of the RCA Member States and with copies sent direct to the Project national counterparts. Following this action, I have arranged to have a complete set of draft guidelines and text books on NDT subjects (4 volumes) sent from Vienna direct to national counterpart institutions, and you should have received these materials by the end of January 1984.

In the event that you are not the one assigned to evaluate the proposal on NDT Regional Training and Certification Scheme, I hope that the relevant materials and our request to receive your Government's views and advices on the subject matter by 15 April 1984 have already been passed on to a proper competent body in your country.

In this connection, I would like to know through you how far the evaluation of our proposal has proceeded. I should also be grateful if you will give me the name and full address of the competent body that has been designated to review our proposal and, if possible, a copy of your relevant communications with this body which I may quote.

I still have in my office a few more sets of the draft guidelines and training manuals on NDT. Please let me know if you want another set, or want it to be forwarded to any other competent body in your country.

I hope I am not asking too much from you.

With best personal regards, I look forward to hear from you again soon.

Yours sincerely,

S.P. Kasemsanta

Sobhak P. Kasemsanta
Project Co-ordinator

April 1984

WORK PLAN
UNDP REGIONAL INDUSTRIAL PROJECT
1984

JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE
1.1 Sub-Proj. 4.c First Training-Demo. OSAC Mineral Concentr. 2nd Part, Group B Philippines 8 Jan-31 March 1.2 Market Studies and Planning of Executive Management Seminar (Jan-Dec.84) 1.3 Expert - Tracer Technology, 1 week Singapore		3.1 Sub-Project 1 1st Training-Demonstr. Tracer Techn.in Industry Bombay 1-23 March Singapore 24-30 March 3.2 Expert - Tracer Technology, 2 weeks Singapore 3.3 Sub-Project 4.a 3rd Training-Demo. Nucl.Control Systems for Paper Manufacture BanPong, Thailand 12-25 March; Japan 26-30 March 3.4 Training (2) Operations and Mainten. of EB Machine, Kyoto Japan (4 weeks) 3.5 Evaluation Questionnaire to all participants and training courses	4.1 Sub-Project 3.a Second In-Resident Training Radiation Vulcanization of Natural Rubber Latex 1 April - 30 Sept. Jakarta 4.2 Start Desk Evaluation Review (DER) of Sub-Project 4.a	5.1 Sub-Project 2 7th NDT Expert Working Group Meeting, Bangkok 22-25 May 5.2 Analysis of Evaluation of Training Courses DER of Sub-Project 4.a completed	6.1 4th SBA Meeting Adelaide, Australia 18-21 June 6.2 Sub-Project 4.c Executive Management Seminar - Minerals Processing, Baguio, Philippines 11-12 June

	PC Travel	PC Travel		PC Travel	PC Travel
1.1 Requirement: Australian Arrange- ments and Contrib. to Project 1.2 Requirement: Total 1984 Cost (Planned): US$70,875 RAS/8/008 1.3 Requirement: Issuance of (1) Special Serv.Agreem. Cost: US$1,530 RAS/8/008		3.1 Requirement: Issuance of (12) Training Agreements Cost: US$ 35,000 RAS/8/008 3.2 Requirement: Issuance of (2) Training Agreements Cost: US$ 7,500 RAS/8/008 3.3 Requirement Issuance of (12) Training Agreements Cost: US$35,000 RAS/8/008 US$ 10,000 Japan Contrib. 3.4 Requirement: Issuance of (2) Training Agreements 2m/m; Cost: US$7,000 Japan Contrib.	4.1 Requirement: Issuance of (8) Training Agreements Cost: US$ 53,000 RAS/8/008 Issuance of (4) Lecture Agreements Cost: US$12,000 Japan Contrib.	5.1 Requirement: Issuance of (6) Special Service Agreements Cost: US$ 11,000 Japan Contrib.	6.1 Requirement: Issuance of (5) Special Service Agreements Cost: US$ 8,000 RAS/8/008 6.2 Requirement: Issuance of (7) Special Service Agreements Cost: US$ 20,000 RAS/8/008

April 1984

WORK PLAN
UNDP REGIONAL INDUSTRIAL PROJECT
1984

JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
7.1 Sub-Proj. 3.a(2) EBM Wood Pilot Facility EBM/Wood Test Operations and Dosimentry, Jakarta (Ref.Pilot Plant Work Schedule) One Expert Wood Handling Machine (5 weekd from mid-July) One Expert Dosimetry (5 weeks from mid Aug.) Pre-Operation testing and Commissioning (1.5 m/m)	8.1 Preparation of Draft Report on Mid-term Project Review	9.1 Sub-Project 3.b 2nd Training-Demonstr. Radiation Steriliz. of Medical Products Bombay 10-22 September Seoul 23-29 Sept. 9.2 Sub-Project 4.a Executive Management Seminar - Paper Ind. Bangkok 27-28 Sept. 9.3 Sub-Project 5 Training Seminar Ind. Nucleonic Instrument. Engineering, Tokyo 10-28 September 9.4 Sub-Project 3.a Third Technical Review Meeting on Rad.Proc. Jakarta (5 days) 9.5 Sub-Project 3.a (2) EBM/Wood Commissioning of Pilot Facility for Rad.Curing of Wood Surface Coatings, Jakarta	10.1 Sub-Project 2 3rd (SING) Training Course Advanced NDT Practice, Singapore 1-19 October 10.2 Sub-Project 3.a EBM/Wood, First In-Resident Training Radiation Curing of Wood Surface Coatings Jakarta 1 Oct.1984 to 30 March 1985 10.3 Sub-Project 4.b 2nd Training Demo. Nucleonic Control Systems in Steel Ind. Bokaro, India 9-23 Oct. Tokyo 24-31 October	11.1 Preparation of Interim Report on Mid-term Project Review 11.2 Full Scale Tripartite Review Jakarta	12.1 5th SBA Meeting 3 days 12.2 Sub-Project 4.b Executive Management Seminar - Steel Ind. Bokaro, India 5-6 December

	PC Travel	PC Travel		PC Travel
7.1 Requirement: Issuance of (a) Spec. Service Agreements (2) Cost: US$ 4,000 Japan Contribution (b) Services Contract for Pre-operation testings, etc. Cost: US$ 10,000 Japan Contribution	9.1 Requirement: Issuance of (12) Training Agreements Cost: US$ 35,000 RAS/8/008 9.2 Requirement: Issuance of (7) Special Service Agreem. Cost: US$20,000 RAS/8/008 9.3 Requirement: Issuance of (15) Training Agreements Cost: US$52,000 Japan Contribution 9.4 Requirement: Issuance of (14) Special Service Agreem. Cost: US$ 23,000 Japan Contribution 9.5 Requirement: Issuance of (2) Spec. Service Agreements Cost: US$ 3,900 Japan Contribution	10.1 Requirement: Issuance of (10) Training Agreements Cost: US$ 35,000 RAS/8/008 US$ 12,000 Equipment , provisions, RAS/8/008 US$ 5,000 Japan Contr. 10.2 Requirement: Issuance of (5) Training Agreements Cost: US$ 30,000 RAS/8/008 US$12,000 Japan Contr. 10.3 Requirement: Issuance of (12) Training Agreements Cost: US$ 35,000 RAS/8/008 US$10,000 Japan Contr.	11.2 Requirement: Issuance of (4) Special Service Agreements Cost: US$ 10,000 RAS/8/008	12.1 Requirement: Issuance of (5) Special Service Agreements Cost: US$ 8,000 RAS/8/008 12.2 Requirement: Issuance of (7) Special Service Agreements Cost: US$ 20,000 RAS/8/008

INTERIM REPORT ON MID-TERM PROJECT REVIEW/TIMETABLE

1. Brief interim reports in the form of the final project evaluation of each sub-project to be sent to Mr. Kasemsanta (SPK) by mid-May 1984

   Responsibility - NCp's or SBA

2. SBA members to send separate comments to Mr. Kasemsanta re potential for programme extension, by mid-May 1984.

   Responsibility - SBA

3. Distribution of collated reports to SBA by early June.

   Responsibility - SPK

4. Discussion at Adelaide Board Meeting

   Responsibility - SBA

5. Amended reports for mid-term project review to be sent to Mr. Kasemsanta by end of July

   Responsibility - NCp's, SBA

6. Mr. Kasemsanta to draft mid-term project review in collaboration with Mr. Fowler (EEF)

   Responsibility - SPK, EEF

7. Submit to Board by end of September.

   Responsibility - SPK

8. Comments to Mr. Kasemsanta by late October

   Responsibility - SBA

9. Mid-term report to Board by mid-November

   Responsibility - SPK

10. Discussion at December Board Meeting, presentation of report to UNDP by end of year

    Responsibility - SBA

UNITED NATIONS DEVELOPMENT PROGRAMME

PROJECT REVISION FORM

Country:	Asia and the Pacific
Project Title:	Support for Regional Co-operation in the Industrial Application of Isotopes and Radiation Technology
Project No.:	RAS/79/061/I/01/18

The above project is amended as indicated to reflect rephasings of provisions in accordance with present plans for implementation.

The change to the project budget - UNDP input is as follows:

Previous UNDP input	- Project budget RAS/79/061/H	$4,255,927
Revised UNDP input	- Project budget RAS/79/061/I	$4,255,927
UNDP input	- increase/decrease	-

R. Helmke
Head, Programme Co-ordination Section
Department of Technical Co-operation
Agreed on behalf of the Executing Agency ____________ Date

Approved on behalf of UNDP ____________ Date

PROJECT BUDGET COVERING UNDP CONTRIBUTION
(In U.S. Dollars)

Country: Asia and the Pacific
Project No.: RAS/79/061/I/01/18
Project Title: Support for Regional Co-operation in the Industrial Application of Isotopes and Radiation Technology (Summary)

		Total		1979		1980		1981		1982		1983		1984		1985		1986	
		m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$
10.	PROJECT PERSONNEL																		
11.	EXPERTS																		
11-01	Chief Techn.Adviser	19.5	121,056		-	4.5	33,333	12.0	69,345	3.0	18,378		-		-		-		-
11-02	Consultants	19.0	183,757		-	3.8	32,584	1.2	14,173		-	5.5	54,000	2.5	23,000	3.0	30,000	3.0	30,000
11-03	Tracer technology in industry	2.5	21,400		-		-		-	1.5	10,400		-	0.5	5,000		-	0.5	6,000
11-04	Non-destructive testing		-		-		-		-		-		-		-		-		-
11-05	Radiation Processing	2.7	22,692		-		-		-	1.7	16,692	1.0	6,000		-		-		-
11-06	Nucleonic Control Systems-Paper manufacture		-		-		-		-		-		-		-		-		-
11-07	Nucleonic Control Systems-Steel manufacture	0.2	1,975		-		-		-	0.2	1,975		-		-		-		-
11-08	Nucelonic Control Systems-Minerals	0.2	2,200		-		-		-	0.2	2,200		-		-		-		-
11-09	Nuclear Instruments Maintenance	0.4	5,500		-		-		-		-		-	0.2	2,500		-	0.2	3,000
11-99	Sub-total	44.5	358,580		-	8.3	65,917	13.2	83,518	6.6	49,645	6.5	60,000	3.2	30,500	3.0	30,000	3.7	39,000
13.	Administrative support personnel																		
13-01	Secretary		54,371		-		5,113		14,132		15,926		19,200		-		-		-
15.	Travel on official business		198,978		-		10,130		30,234		34,614		37,000		30,000		30,000		27,000
16.	Other costs (mission)		40,631		13,535		2,939		1,323		4,834		3,000		5,000		5,000		5,000
18.	Savings on liquidation of prior years' obligations		(3,932)		-		(2,873)		(3,226)		2,167		-		-		-		-
19.	Component Total		648,628		13,535		81,226		125,981		107,186		119,200		65,500		65,000		71,000
20.	SUB-CONTRACTS																		
21.	Market Studies		93,000		-		-		-		-		22,125		70,875		-		-
29.	Component Total		93,000		-		-		-		-		22,125		70,875		-		-
30.	TRAINING																		
31.	Individual Fellowships		-		-		-		-		-		-		-		-		-
32.	Group Training		1,297,726		-		42,572		86,499		110,079		170,000		250,100		335,000		303,476
38.	Savings on liquidation of prior years' obligations		(919)		-		-		(273)		(646)		-		-		-		-
39.	Component total		1,296,807		-		42,572		86,226		109,433		170,000		250,100		335,000		303,476
49.	EQUIPMENT		2,177,702		-		-		831,202		699,500		567,000		55,000		25,000		-
59.	MISCELLANEOUS		39,790		-		-		45		2,720		2,000		7,025		11,000		17,000
99.	GRAND TOTAL		4,255,927		13,535		123,798		1,043,454		918,839		880,325		448,500		436,000		391,476

PROJECT BUDGET COVERING UNDP CONTRIBUTION
(in U.S. Dollars)

Country: Asia and the Pacific
Project No.: RAS/79/061/I/01/18
Project Title: Support for Regional Co-operation in the Industrial Application of Isotopes and Radiation Technology
Sub-Project 1: Tracer Technology in Industry

		Total		1982		1983		1984		1985		1986	
		m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$
10.	PROJECT PERSONNEL												
11.	Experts												
11-03	Tracer technology in Industry	2.5	21,400	1.5	10,400		-	0.5	5,000		-	0.5	6,000
19.	Component total	2.5	21,400	1.5	10,400		-	0.5	5,000		-	0.5	6,000
30.	Training												
32.	Group Training		95,350		-		-		53,000		-		42,350
39.	Component total		95,350		-		-		53,000		-		42,350
49.	Equipment		109,720		-		29,720		55,000		25,000		-
99.	UNDP Total Contribution		226,470		10,400		29,720		113,000		25,000		48,350

PROJECT BUDGET COVERING UNDP CONTRIBUTION

(in U.S. Dollars)

Country: Asia and the Pacific
Project No.: RAS/79/061/I/01/18
Project Title: Support for Regional Co-operation in the Industrial Application of Isotopes and Radiation Technology
Sub-Project 2: Non-Destructive Testing

		Total		1980		1981		1982		1983		1984		1985		1986	
		m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$
10.	PROJECT PERSONNEL																
11.	Experts																
11-04	Non-destructive Testing		-		-		-		-		-		-		-		-
19.	Component Total		-		-		-		-		-		-		-		-
30.	Training																
.32.	Group Training		210,758		42,572		-		34,336		35,000		18,000		38,500		42,350
39.	Component total		210,758		42,572		-		34,336		35,000		18,000		38,500		42,350
49.	Equipment		51,932		-		-		51,932		-		-		-		-
99.	UNDP Total Contribution		262,690		42,572		-		86,268		35,000		18,000		38,500		42,350

PROJECT BUDGET COVERING UNDP CONTRIBUTION

(In U.S. Dollars)

Country: Asia and the Pacific
Project No.: RAS/79/061/I/01/18
Project Title: Support for Regional Co-operation in the Industrial Application of Isotopes and Radiation Technology
Sub-Project 3: Radiation Processing

		Total		1981		1982		1983		1984		1985		1986	
		m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$
10.	PROJECT PERSONNEL														
11.	Experts														
11-05	Radiation Processing	2.7	22,692		-	1.7	16,692	1.0	6,000		-		-		-
19.	Component Total	2.7	22,692		-	1.7	16,692	1.0	6,000		-		-		-
30.	TRAINING														
31.	Ind. Fellowships		-		-		-		-		-		-		-
32.	Group Training		444,676		-		-		55,000		109,100		146,500		134,076
39.	Component total		444,676		-		-		55,000		109,100		146,500		134,076
49.	EQUIPMENT		1,366,752		549,702		291,465		525,585		-		-		-
99.	UNDP Total Contribution		1,834,120		549,702		308,157		586,585		109,100		146,500		134,076

PROJECT BUDGET COVERING UNDP CONTRIBUTION

(in U.S. Dollars)

Country: Asia and the Pacific
Project No.: RAS/79/061/I/01/18
Project Title: Support for Regional Co-operation in the Industrial Application of Isotopes and Radiation Technology
Sub-Project 4: Nucleonic Control Systems

		Total		1981		1982		1983		1984		1985		1986	
		m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$
10.	PROJECT PERSONNEL														
11.	Experts														
11-06	Paper manufacture		-		-		-		-		-		-		-
11-07	Steel manufacture	0.2	1,975		-	0.2	1,975		-		-		-		-
11-08	Minerals exploration	0.2	2,200		-	0.2	2,200		-		-		-		-
19.	Component Total	0.4	4,175		-	0.4	4,175		-		-		-		-
40.	TRAINING														
32.	Group Training		360,715		-		35,015		54,000		70,000		117,000		84,700
39.	Component total		360,715		-		35,015		54,000		70,000		117,000		84,700
49.	EQUIPMENT		637,603		281,500		356,103		-		-		-		-
99.	UNDP Total Contribution		1,002,493		281,500		395,293		54,000		70,000		117,000		84,700

PROJECT BUDGET COVERING UNDP CONTRIBUTION

(in U.S. Dollars)

Country: Asia and the Pacific
Project No.: RAS/79/061/I/01/18
Project Title: Support for Regional Co-operation in the Industrial Application of Isotopes and Radiation Technology
Sub-Project 5: Nuclear Instruments Maintenance

		Total		1981		1982		1983		1984		1985		1986	
		m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$
10.	PROJECT PERSONNEL														
11.	Experts														
11-09	Nuclear Instruments Maintenance	0.4	5,500		-		-		-	0.2	2,500		-	0.2	3,000
19.	Component Total	0.4	5,500		-		-		-	0.2	2,500		-	0.2	3,000
30.	TRAINING														
31.	Ind. Fellowships		-		-		-		-		-		-		-
32.	Group Training		186,227		86,449		40,728		26,000		-		33,000		-
38.	Savings on liquidation of prior year's obligation		(919)		(273)		(646)								
39.	Component total		185,308		86,226		40,082		26,000		-		33,000		-
49.	EQUIPMENT		-		-		-		-		-		-		-
99.	UNDP Total Contribution		190,808		86,226		40,082		26,000		2,500		33,000		3,000

PROJECT BUDGET COVERING UNDP CONTRIBUTION
(In U.S. Dollars)

Country: Asia and the Pacific
Project No.: RAS/79/061/I/01/18
Project Title: Support for Regional Co-operation in the Industrial Application of Isotopes and Radiation Technology
Project Management and Co-ordination

		Total		1979		1980		1981		1982		1983		1984		1985		1986	
		m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$	m/m	US$
10.	PROJECT PERSONNEL																		
11.	Experts																		
11-01	Chief Techn.Adviser	19.5	121,056		-	4.5	33,333	12.0	69,345	3.0	18,378		-		-		-		-
11-02	Consultants	19.0	183,757		-	3.8	32,584	1.2	14,173		-	5.5	54,000	2.5	23,000	3.0	30,000	3.0	30,000
11-99	Component Total	38.5	304,813		-	8.3	65,917	13.2	83,518	3.0	18,378	5.5	54,000	2.5	23,000	3.0	30,000	3.0	30,000
13.	Administrative support personnel																		
13-01	Secretary		54,371		-		5,113		14,132		15,926		19,200		-		-		-
15.	Travel on official business		198,978		-		10,130		30,234		34,614		37,000		30,000		30,000		27,000
16.	Other costs (mission)		40,531		13,535		2,939		1,323		4,834		3,000		5,000		5,000		5,000
18.	Savings on liquidation of prior years' obligations		(3,932)		-		(2,873)		(3,226)		2,167		-		-		-		-
19.	Component Total		594,861		13,535		81,226		125,981		75,919		113,200		58,000		65,000		62,000
20.	SUB-CONTRACTS																		
21.	Market Studies		93,000		-		-		-		-		22,125		70,875		-		-
29.	Component Total		93,000		-		-		-		-		22,125		70,875		-		-
49.	Equipment		11,695										11,695						
59.	Miscellaneous		39,790		-		-		45		2,720		2,000		7,025		11,000		17,000
99.	UNDP Total Contribution		739,346		13,535		81,226		126,026		78,639		149,020		135,900		76,000		79,000

1984 RCA Action Plan

(Estimated Costs)

Project Title	1984 Total Costs (Contracts, meetings, etc.)
UNDP Project on Industrial Applications of Isotopes and Radiation Technology	$ 1,621,059 [1)]
The Use of Induced Mutations for Improvement of Grain Legume Production	60,000
Food Irradiation	90,000 [2)]
Nuclear Techniques to Improve Domestic Buffalo Production	85,000
Sterilization of Biological Tissue Grafts	30,000
Health-related Environmental Research	4,000
Maintenance of Nuclear Instruments	60,000
Basic Science using Research Reactors	40,000 [3)]
Isotope Applications in Hydrology and Sedimentology	25,000
Semi-dwarf Mutants for Rice Improvement	48,000
Imaging Procedures for Diagnosis of Liver Diseases	60,000 [4)]
Improvement of Cancer Therapy	230,000 [5)]
Nuclear Techniques for Tropical Parasitic Diseases	62,500
Development of Tc-99m Generator Systems	35,000 [6)]
Working Group Meeting	4,000
TOTAL	$ 2,454,559

1) The project on Industrial Applications of Isotopes and Radiation Technology is funded by UNDP at a level of US$448,500; by RCA Governments at a level of US$1,025,290; and by industries at a level of US$147,269.

2) Not yet available. Under negotiation with RCA Governments.

3) To be funded out of the special contribution of US$50,000 by the Government of India.

4) Most of the cost (US$50,000) will be borne by an expected contribution by the Government of Japan.

5) Part of the cost (US$40,000) will be borne by an expected contribution by the Government of Japan. This total includes two training courses (US$160,000) funded by IAEA tehcnical cooperation funds.

6) Out of the special contribution of US$50,000 by the Government of India, US$10,000 will be used to fund a training workshop.

1985 RCA Cost Projection

Project Title	1985 Total Cost (US$)
UNDP Project on Industrial Applications of Isotopes and Radiation Technology	1,316,156 [1)]
The Use of Induced Mutation for Improvement of Grain Legume Production	27,000
Food Irradiation	90,000 [2)]
Nuclear Techniques to Improve Domestic Buffalo Production	73,000
Sterilization of Biological Tissue Grafts	41,000
Health-related Environmental Research	55,000
Nuclear Instrument Maintenance	65,000
Basic Science using Research Reactors	27,000 [3)]
Isotope Applications in Hydrology and Sedimentology	12,000
Semi-dwarf Mutants for Rice Improvement	73,000
Improvement of Cancer Therapy	150,000 [4)]
Imaging Procedures for Diagnosis of Liver Diseases	210,000 [5)]
Nuclear Techniques for Tropical Parasitic Diseases	87,900 [6)]
Development of Tc-99m Generator Systems	100,000 [7)]
Working Group Meeting	4,000
TOTAL	2,331,056

1) The project is funded by UNDP at a level of $436,000; by RCA Governments at a level of US$734,327; and by industries at a level of US$145,829.
2) Cost expected to be covered by donor countries contributions. (Includes cost of one workshop - $50,000).
3) To be funded by the Indian Government.
4) Part of the cost will be borne by an expected contribution by the Government of Japan. (Includes one training workshop - $80,000).
5) Part of the cost will be borne by an expected contribution by the Government of Japan. Includes two training workshops (US$90,000 and US$60,000).
6) Includes one training course (US$35,000).
7) Includes one training course (US$60,000).

SUMMARY OF PROPOSAL FOR RCA COORDINATED RESEARCH PROGRAMME ON IMAGING PROCEDURES FOR DIAGNOSIS OF LIVER DISEASES

This proposal was developed in a Consultants' Meeting at IAEA Headquarters on 5 - 6 March attended by Drs. T.A. Iinuma, K. Mamiya, and Y. Tateno from Japan, Dr. R. Höfer from Vienna, and Drs. R.A. Dudley, M. Nofal and A. Wegst from the IAEA.

1. Proposed title of programme

Coordinated Research Programme on the Quantitative Evaluation of Nuclear Medicine Imaging Procedures for the Diagnosis of Liver Diseases.

2. Summary of proposal

The programme will provide the framework between institutes in the RCA countries for the quantitative evaluation of the reliability of nuclear medicine imaging procedures for the diagnosis of liver diseases, and for initiating improvements in these procedures.

3. Scientific background

At nuclear medicine units in the RCA countries, patients with liver disease consitute one of the largest groups referred for in-vivo radionuclides investigations. The most common procedure carried out on these patients is the imaging of phagocytic activity of the RES system in the liver via labelled colloidal particles. The most common objective of this procedure is the detection of space-occupying lesions in the liver, as may result from primary hepatoma, pseudotumour, benign neoplasm, metastasis, haemorrhage, abscess, cyst, infarct, subphrenic abscess, etc.

At present, radionuclide images of the liver are obtained by two types of instruments, rectilinear scanners and gamma cameras. In developed countries, scanners are no longer commonly used; in developing countries, on the other hand, they remain the only imaging instrument available in many units. The optimal choice of imaging method is not the same in all countries, but depends on local conditions including type of instrument, objectives, and local resources.

4. Objectives of the programme

The detailed objectives of the programme are: (1) to investigate the current capability of laboratories to detect simulated lesions in a standardized liver phantom, as influenced by the performance of the instrument and of the physician interpreting the images, (2) to initiate measures designed to improve the performance of the instrument and the reliability of the observer, (3) to investigate the current diagnostic reliability of nuclear medicine imaging procedures to detect space-occupying lesions in the liver of patients. The overall objective is to improve the diagnostic efficacy of radionuclide imaging in liver disease.

5. Participants

Leading nuclear medicine laboratories with experience in the investigation of liver disease in RCA countries will be invited to participate under Research Contracts or Agreements.

6. Work plan and implications for the future

The project will be initiated in 1984, and, subject to reevaluation as it proceeds, is expected to be concluded in 1988.

Prior to initiation of measurements in the project, all participating laboratories will be requested to collect information from laboratories in their countries that perform liver imaging with radionuclides. This will include factual data on the identity of all such laboratories, the equipment available in each for imaging by radionuclide or other means and the operational status of the instruments, the radiopharmaceuticals employed, and the number of patients routinely studied per year with their disease spectrum.

The first phase of the project will be a baseline investigation of the current capabilities of the participating laboratories in performing liver imaging and in interpreting images. The Agency will make available to all laboratories a transmission phantom simulating a liver with multiple space occupying lesions; participating laboratories will record and interpret images of the phantom and report the results to the Agency and Japanese co-ordinators, both of whom will then analyze the ensemble of results. Japanese collaborating laboratories will concurrently distribute to the participating laboratories sets of images from actual livers and analogues of the phantom for appraisal of observers performance. The liver images, about 100 in number, will be selected from those already available on Japanese patients having diverse liver diseases and independent confirmation of their status as to space occupying lesions; the phantom images, only a few in number, will be prepared on modified versions of the foregoing phantom. The laboratories will interpret these images and report their findings to the Japanese collaborators for analysis using techniques already applied in Japan.

The second phase of the project, which in time will overlap the first and third phases, will stimulate improvements in the performance of participating laboratories to record and interpret images if such is found desirable in the first phase. This will be accomplished in part by guidance as to quality control of imaging instruments, and may be aided by a training course.

The details of the third phase of the study will be formulated in the light of experience from the first 2 phases; in general it will test performance in a more explicit clinical setting. Present expectations are that a further set of liver images from actual patients with independently confirmed status as to space occupying lesions will be collected by the participating laboratories themselves. These will be circulated as in the first phase for interpretation "blind" by all laboratories, and the Japanese collaborators will again analyze the ensemble of reported interpretations in the light of the "true" status of each liver. This will lead to an assessment of the current ability of participating laboratories to detect space occupying lesions of the liver as found in typical cases from the Region.

Progress in the project will be monitored and plans formulated at co-ordination meetings convened approximately yearly. The first meeting should preferably be held in conjunction with the Asian and Oceanian Congress of Nuclear Medicine in Seoul, August 1984.

WORK PLAN

Initiative Date	Meeting	Work
April-August, 1984		Identification of participating laboratories, collection of information on liver imaging in respective countries.
August 1984	Specialists' meeting (Seoul) to design study and make detailed plans for first phase.	
September 1984 - August 1985		Conduct first phase of study on phantom and Japanese liver images.
August 1985	First coordination meeting to review accomplishments, refine further plans.	
September 1985 - Autumn 1986		Conduct training activities to improve laboratory performance. Start third phase of project on collection and interpretation of images from participating countries if found appropriate from preceding experience.
Autumn 1986	Second coordination meeting.	
Autumn 1986 - Autumn 1987		Proceed with third phase and further training.
Autumn 1987	Third coordination meeting	
1988	Last coordination meeting.	Completion of study

PROPOSED SCHEDULE FOR FIRST COORDINATION MEETING
(preferably Seoul, 22-24 August 1984)

First Day

Registration
Welcome
Adoption of agenda
Overview of project: Japanese and IAEA organizers
Country reports on liver imaging: all participants

Second Day

Completion of country reports
Plans for liver phantom: IAEA
- Purpose
- Measurements and interpretation
- Analysis
- Establishment of plans and schedule

Plans for Japanese liver images: Japanese organizers
- Summary of completed Japanese project
- Requirements for interpretation of images
- Analysis
- Establishment of plans and schedule

Third Day

Discussion of methods to up-grade performance
Discussion of third phase
- Formulation of questions whose answers would be most useful to understand and improve status of liver imaging
- Possibilities for collection of liver images
- Possibilities for independently confirming presence or absence of space occupying lesions
- Selection of cases

Energy from Agricultural and Agroindustrial Residues Through Use of Radiation and Industrial Microorganisms.

1. Scientific Background of the Project

1.1. Introduction:

It is being increasingly realized that with the present accessible reserves of coal, gas and oil it will be impossible to meet the world energy demand by the end of this century. Though there is some disagreement on when the present reserve of fossil fuels will decline, but there is no disagreement over the fact that the decline is enevitable. In anticipation of this fact much interest has developed recently in the search for alternative sources of energy. Nuclear energy is obviously a potential alternative to meet the energy need and development of nuclear technology is essential to exploit this potential source. On the other hand bioenergy technologies are examples of soft-energy paths which can go a long way in solving the problem of energy, feed and food. Application of nuclear technology in bioconversion strategies will greatly improve the efficiency of the process.

1.2. Biomass resources:

Biomass in the form of cellulose, hemicellulose and lignin provides a means of collecting and storing solar energy and hence represents an important energy and material resource. It has been estimated that about 7.3×10^{14} pounds of CO_2 are fixed on the earth per year and 6% of this end up as cellulose. Annually available cellulose is little over double the present consumption of fossil fuels and the amount can be increased. Less than 1% of the sunlight falling on this earth is utilized photosynthetically and there is ample scope for increasing the efficiency. Residues from agricultural and agroindustrial processes represent a good source of biomass (Appendix 1) and because of their present uneconomic and inefficient uses, there is great scope for using them for the development of alternative sources of energy and other useful chemicals (Appendix 11).

Before using any biomass resource it is necessary to convert it into a usable form such as gaseous (methane) or liquid (ethanol) feed stock that fits into our chemical economy.

2. Steps For Energy Through Bioconversion

Any bioconversion strategy for energy from agricultural residues has to undergo following steps:

1. Pretreatment
2. Enzyme production
3. Saccharification/hydrolysis
4. Fermentation to ethanol

2.1. Pretreatment:

All cellulosic materials (agricultural, agroindustrial, urban refuse etc.) are relatively hard to degrade because of their crystallinity and association with other noncellulosic substances. The objective of pretreatment is to make cellulosic biomass more amenable to degradation. Both physical and chemical pretreatment methods are available. Physical pretreatments include size reduction by ball milling, use of gamma ray etc. and chemical pretreatments involve use of acid, alkali, solvents etc. Which pretreatment will be suitable for a process depends on the nature of the substrate, efficiency and cost involved. Pretreatments contribute a major cost factor to bioconversion of cellulosic substances. Hence pretreatment methods have to be optimized to get maximum efficiency with minimum cost.

2.2. Enzyme production

2.2.1. Fungal and bacterial system:

Both fungal and bacterial systems have been exploited for production of cellulase enzyme required for saccharification of celluloses. At present *Trichoderma* is regarded as the best source of enzymes. However, other fungal sources have been found to have great potential. Among bacterial system Cellulomonas, Pseudomonas etc. are good organisms for degradation of cellulosics. There is great potential for improvement of both fungal and bacterial system through mutation and selection.

2.2.2. Microbial cell/enzyme immobilization:

Recent development in this field is the immobilization of microbial cells for increased production of enzymes. The same immobilization method is employed for stability and thus increasing activity of enzymes.

Four methods of immobilization of microbial cells or enzymes include covalent attachment entrapment (including micro-encapsulation), adsorption and crosslinking leading to insoluble aggregates. Of the various procedures, entrapment within a network of different gels. is the most widely used method. It has been reported that *T. reesei* immobilized on Celite produces good yield of cellulase and better specific activity. Similarly B-glucosidase from *Thermomospora* immobilized on Amberlite anion and cation exchange resins resulted in better stabilization of the system.

3. Saccharification/Hydrolysis

3.1. Batch and continuous hydrolysis:

Once a good source of enzyme is obtained, and the production condition has been optimized, next step is the development of appropriate saccharification system. Enzyme/substrate mixing, p^H, temperature and other environmental conditions have to be optimized. Most saccharifying enzymes are sensitive to product inhibition so that reaction slows down with the accumulation of fermentable sugars. This necessiates proper reactor design to separate the product from the reaction mixture. Development of continuous hydrolysis process requires development of proper systems for enzyme substrate mixing and product recovery. Research in this line is very essential for development of the system.

3.2. Hydrolysis by immobilized enzymes:

This has been discussed in section 2.2.2.In saccharification, immobilization may help in releiving feed back inhibition, because of separation of product from the enzyme.

4. Ethamol Fermentation

4.1. Batch and continuous fermentation using yeast and bacteria:

Once fermentable sugars are obtained from cellulosic substances, conversion to alcohol occurs through fermentation using the yeast *Sacharomyces cerevisiae.* Recent investigations have indicated that bacterium *Zymomonas mobilis* can produce alcohol at faster and higher rate than the yeast and needs to be evaluated for alcohol production from cellulosic hydrolysaes. Alcohol fermentation can be done in both batch and continuous way and process strategy depends on various factors such as yield, ease of operation, product recovery etc. Use of immobilized yeast cells have been reported to give good yield of alcohol.

4.2. Simultaneous saccharification and fermentation:

Since accumulation of sugars inhibit saccharification, simultaneous fermentation of the saccharified sugar would relieve product inhibition. Inoculation of yeast under proper environmental conditions in the hydrolysis reactor maintaining ascepsis of the process can convert sugar into alcohol and simultaneously saccharification can take place. Improved yield of sugar and alcohol has been reported using simultaneous saccharification and fermentation.

4.3. Direct conversion of cellulose to alcohol:

Some microbial species have been reported to be able to convert cellulose into alcohol so that saccharification step can be avoided. These include *Fusarium*, *Clostridium*, *Neurospora* etc. though the yield is not high. However, they represent a potential biological converter to be explored for single step bioconversion of cellulosics to alcohol.

5. <u>Research Objectives</u>

In the light of above back ground and scientific information cited it is submitted that a Bioconversion programme for to production of energy from agricultural and agroindustrial residues be undertaken under RCA.

The objectives are:

(i) To assess potential of different locally produced agricultural and agroindustrial resources as raw materials for conversion to liquid fuel. Alternative uses are to be taken into account for assessment of comparative benefit.

(ii) To develop an economic pretreatment method for bioconversion of residues to alcohol fuels.

(iii) To develop a good enzyme system for obtaining fermentable sugars from residues and a good microbial system for conversion to alcohol.

(iv) To optimize the conversion process comparing different strategies.

6. <u>Detailed Work Plan</u>

6.1. <u>Development of pretreatment condition:</u>

Development of an economic and efficient pretreatment method will be attempted for selected agricultural and agroindustrial residues so that efficiency of bioconversion is significantly enhanced. Both physical such as use of steam under pressure, gamma ray etc. and chemical such as use of alkali, acid, solvent etc. and also a conbination of both the pretreatments will be undertaken to find out optimum pretreatment condition.

6.2. <u>Development of high efficiency enzyme system:</u>

Isolation and selection of high cellulase yielding mutants of microorganisms.

Both fungal and bacterial system will be explored. Mutation and screening will be undertaken to improve cellulase yield. UV, gamma ray and NMG will be used as mutagen. Both extracellular and introcellular enzyme preparation will be sought using fungal and/or bacterial system. Recently developed selection techniques will be used for isolating catabolite repression resistant and end product inhibition resistant mutants. In addition proper environmental conditions will be developed for maximum enzyme productivity. Immobilization of microbial cells will be attempted in the light of information cited in 2.2.2.

6.3. Development of saccharification system for fermentable sugars

6.3.1. Batch hydrolysis optimization:

Selected lignocellulosic substances after proper pretreatment will be tested for release of fermentable sugars using the cellulase system. Hydrolysis condition will be optimized in terms of P^H temperature, buffer systems etc. and comparison will be made with existing *T. reesei* system.

6.3.2. Continuous hydrolysis:

Attempts will be made for continuous hydrolysis to improve sugar release by relieving feed back inhibition. Recent developments in the hydrolysis reactor design such as use of semipermeable membrance, counter current hydrolysis system etc. will be applied for improving the system.

6.4. Development of ethanol fermentation system

6.4.1. Ethanol from fermentable sugars:

Fermentation of hydrolysed sugars of lignocellulosic substances will be undertaken using appropriate microbial system. Ethanol fermentation may involve use of the yeast, *Saccharomyes cerevisiae* and/or the bacterium *Zymomonas mobilis* which have been recently reported to give higher yield of alcohol compared to *S. cerevisiae*. Fermentation condition will be optimized for efficient conversion of sugar to alcohol.

6.4.2. Simultaneous saccharification and fermention:

This will be attempted by including the yeast in the hydrolysis reactor under proper environmental condition.

6.4.3. Direct fermentation of cellulosic residues to ethanol:

Attempts will be made to find out suitable microbial system for direct conversion of cellulosics to ethanol. Once a good organism is obtained, improvement will be attempted using both genetic and environmental manipulaion.

7. Conclusion:

Development of renewable resources technology for conversion of agricultural wastes into useful products will be highly beneficial particularly for developing countries. Proper technology for conversion of agricultural residues like bagasses, straw or saw dust into fuel, feed or food involve optimization of different steps in the process. Emphasis on different aspects mentioned in the work plan will vary and will be determined in the light of various developments during the course of work. However, development of the technology will need a coherent progress in different aspects.

8. Literature Citing Recent Developments:

1. Biomass refining Newsletter (Fuel from Biomass) No. 1, 1979; No. 13, 1981.

2. N. Choudhury, P. P. Gray and N. W. Dunn. (1980). Reducing sugar from alkali treated bagasse. Eur. J. Appl. Microbiol. Biotechnol. 11, 50-54.

3. N. Choudhury, N. W. Dunn and P.P. Gray. (1981). Use of combined Cellulomonas and T. reesei preparation for cellulose Saccharification. Biotech. lett. 3, 493-496.

4. V. S. Bisharia and T. K. Ghose. (1981). Biodegradation of Cellulosic Materials. Substrates, Microorganisms, Enzymes and Products. Enzyme and Microbial Technology. Vol. 3, 90-104.

5. M. M. Cheng, T. Y. Chon and G. T. Tsae. (1981). Structures, Pretreatment and Hydrolysis of Cellulose. Adv. Biochem. Engg. vol. 29, 16-50.

6. Y. W. Ham and A. Ciegler. (1982). Use of Nuclear Wastes in Utilization of Lignocellulosic Biomass. Process Biochem. Jan/Feb., 32-42.

7. Y. W. Han and A. Ciegler. (1982). Effect of Gamma Ray Irradiation on Sugar Production from Plant Biomass. Biotech. Bioeng. Symp. No. 12, 73-77.

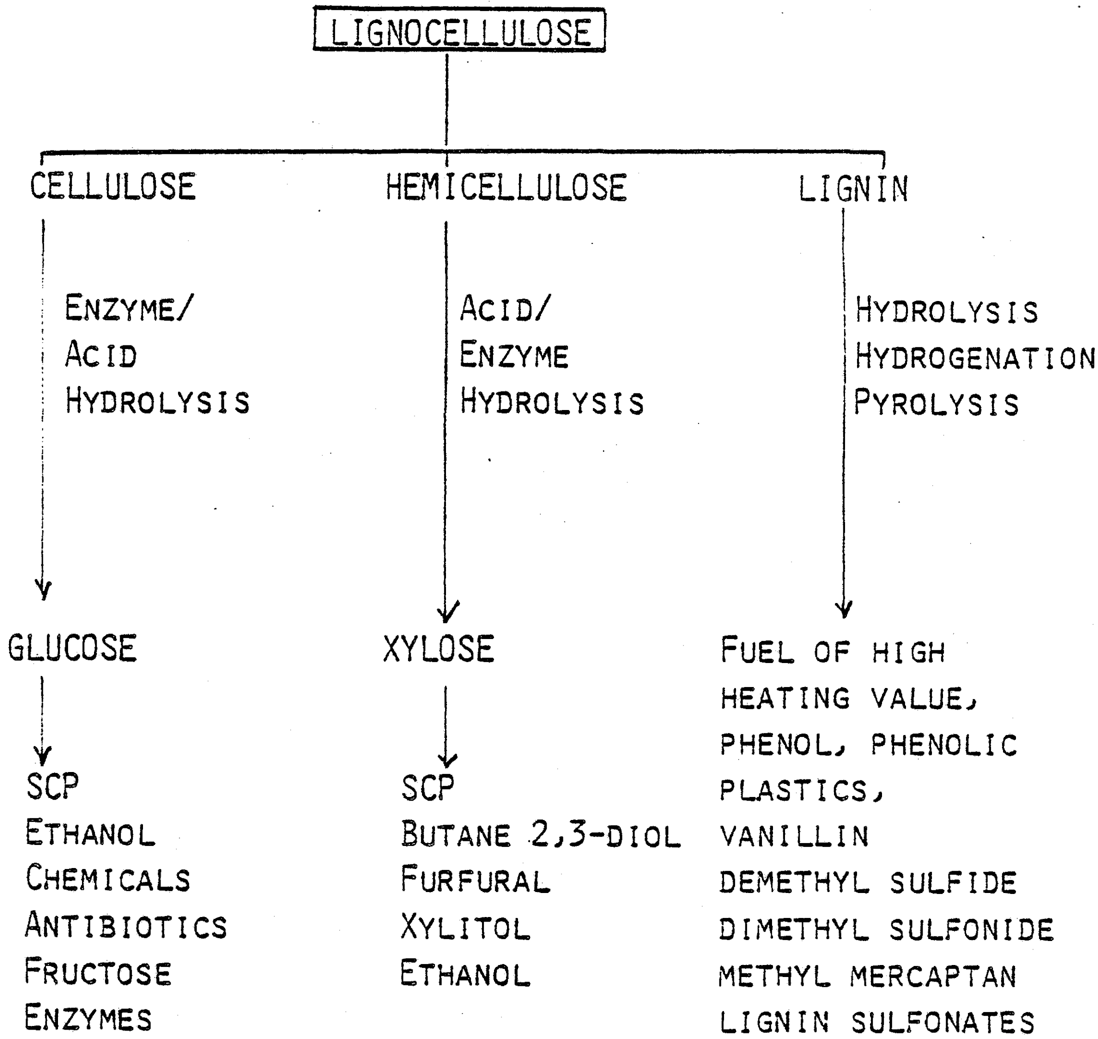
8. Ethanol from Cellulosic Biomass. Wang et. al. (1983). Phil. Trans. R. Soc. London B 300, 723-733.

9. Brown, A. E. (1983). Lignocellulose hydrolysis. Phil. Trans. R. Soc. London, B.S. 305-322.

APPENDIX 1

SOME POTENTIAL AGRICULTURAL AND AGRO-INDUSTRIAL CELLULOSIC RESIDUES

Crop	By-products
	Rice Straw, wheat straw, maize stalk, Castor stem, Tapioca stem, banana stem, coconut stem, Cotton stick, Corn cobs, bamboo dust.
Agro-industrial	
Rice-milling industry	Rice husk, rice bran
Sugar industry	Bagasse, molasses, pressmud
Cotton gining industry	Cotton linters, cotton seed hull, cotton gin waste
Jute industry	Jute sticks, jute mill waste
Saw mill industry	Sawdust
Coconut industry	Coconut husk, shell and pith



APPENDIX 11 : SOME PRODUCTS DERIVABLE FROM LIGNOCELLULOSE

BASIC SCIENCE FOR ADVANCED REACTORS

C.V. SUNDARAM *

INTRODUCTION

THE importance of basic science has been strikingly illustrated in the case of the uranium fission reaction discovered in 1939, and the consequent developments in entirely new fields of science and technology relating to the harnessing of nuclear energy. The enormous impact that this one scientific discovery has made on the world scene is now part of modern history. It is however interesting to recall that the discovery of nuclear fission was in fact a consequence of the experiments by Fermi and his collaborators in an attempt to build up elements heavier than uranium by neutron bombardment of uranium. On the other hand, had scientists deliberately set out to increase the energy output of fossil fired power stations or the yield of the chemical explosives of the day, it is not likely that they would have been working with uranium and neutrons.

On account of the practical significance of the phenomena of nuclear fission and the self-sustained chain reaction, there has been no dearth of financial and other support to all aspects of its exploitation; atomic energy programmes have made rapid progress in many countries. However, even transcending the practical application of the fission reaction for generation of nuclear power, is the associated progress in purely scientific fields. Special mention may be made of the developments in neutron

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physics, the interaction of neutrons with matter leading to understanding of the structure of matter, radiation damage and defect solid state, chemistry and metallurgy of new materials, and applications of radio-isotopes and radiation in agriculture and medicine.

Basic science has played an important role in the development of fission reactor technology and will continue to play such a role for advanced fission reactors like the Fast Breeder Reactor (FBR). Physics has provided the nuclear data and the basis for reactor concepts. Studies in chemistry, materials science and metallurgy have contributed to the development of special reactor materials and an understanding of materials behaviour in reactor environment. Biology has helped to set standards of radiation safety. Engineering sciences have translated the reactor concepts into reality.

Following the successful demonstration and commercial operation of thermal reactors, the stage is now being reached for the establishment of Fast Breeder Reactors for sustaining nuclear power programmes during the next century. Compared to a thermal reactor system, a fast breeder reactor system improves the energy utilisation of natural uranium by a factor of about 60.

2. THE REACTOR RESEARCH CENTRE FOR FAST BREEDER R & D

In order to efficiently utilise the nuclear reserves in India and to sustain a power generation capacity in tune with the needs for the 21st century, it is essential to develop fast breeder reactors. The crucial step towards meeting this requirement was taken in setting up the Reactor Research Centre (RRC) at Kalpakkam, in the early seventies, with the prime objective of indigenous development of the sophisticated technology of plutonium-fuelled Liquid Metal cooled Fast Breeder Reactors (LMFBR). The challenge of proving the engineering feasibility of the LMFBR under Indian conditions was taken up by deciding to construct the 40 MWt Fast Breeder Test Reactor (FBTR) which is now nearing completion at RRC. Simultaneously, laboratories and facilities have been established at RRC for Research & Development programmes in Reactor Engineering and Sodium Technology; Physics and Instrumentation; Metallurgy, Materials Development, and Post-Irradiation Examination; Chemistry & Radiochemistry; Reprocessing & Safety Research.

Basically, an LMFBR has a core made up of small diameter (< 1 cm) stainless steel pins, grouped into subassemblies and supported vertically on a grid plate in a reactor vessel containing liquid sodium. The pins, containing the mixed Pu and U ceramic fuel, are arranged in a tightly controlled geometry with an inter-pin spacing of only 1 to 2 mm, and are required from economic considerations to withstand very high fast neutron flux and fluence levels (10^{15} to 10^{16} n/cm^2 - sec; $\sim 10^{23}$ n/cm^2) and to generate fission heat at high power densities of 300 to 500 kW/l. 'Primary' sodium at temperatures of 350 to 550°C is circulated by sodium pumps at high velocity through the core (a few metres per second) to extract the heat which is transferred through intermediate heat exchangers to non-radioactive 'secondary' sodium, which in turn flows through sodium-heated steam generators to produce steam.

The choice of the LMFBR system to meet the energy requirements of India in the future has far reaching implications on the relevant

R & D efforts. In addition to the sophisticated engineering development work required for the design and fabrication of the reactor components, mechanisms and instrumentation, it is clear that there has to be considerable basic research to ensure and sustain the success of such a venture. Of particular importance will be research in :

a) Metallurgy and physics of fuel and structural materials, and their behaviour under extreme conditions of stress, temperature, fast neutron irradiation and sodium environment.

b) Fabrication and process metallurgy of mixed Pu and U ceramic fuel.

c) Chemistry of the irradiated fuel and the sodium coolant, and their interactions with stainless steel.

d) Process chemistry for the reprocessing of mixed oxide and mixed carbide fuel with high concentration of plutonium, fission products and trans-plutonium elements.

e) Reactor physics, dynamics and safety of sodium-cooled, mixed Pu and U ceramic fuelled fast reactor core under normal and abnormal conditions of operation.

While FBTR has been the focal point for the research activities at RRC in the past decade, the emphasis will progressively shift to the 500 MWe Prototype Fast Breeder Reactor (PFBR) to be designed and constructed over the next decade and half. The sequel illustrates the importance and scope for basic research in this context.

3. FAST REACTOR PHYSICS

Reactor Physics studies are essential for:

- establishing the scientific feasibility of any reactor concept;
- providing the information necessary for the engineering design and the safety analysis of a reactor;
- providing the information necessary for the safe operation of a reactor and following its properties as a function of time.

Reactor physics calculations require a knowledge of the energy variation of the neutron interaction cross-sections of many isotopes to a depth of detail and accuracy not always available in practice. Further, it is required to solve the mathematically complex neutron transport equation involving seven independent variables, which is not always possible for realistic reactor geometries. Hence the calculations need the support of measurements on experimental facilities.

Fast reactor physics has played a very important role in establishing the scientific feasibility of the breeder reactor. The first generation metallic fuelled small sized fast reactors had a hard spectrum with few neutrons in the resonance cross-section energy range. Calculations for such reactors could be made using a 'universal' multigroup set of constants. The early emphasis in fast reactor physics studies was on the breeding ratio, feedback reactivity coefficients and core dynamic stability. With the shift to larger sized oxide fuelled reactors the resonance energy range assumed importance. This caused fast reactor physics to become very complicated with the need to consider the fission and capture reaction resonances of plutonium, uranium and structural materials as well as the scattering resonances of sodium, and the interaction between them. The old idea of a single, universal set of group constants for fast reactors was given up, and extensive, detailed computer programmes were developed for preparing a set of group constants for each particular reactor case taking into account the temperature dependant self-shielding effects of the energy and spatial fine structures.

The fuel expansion coefficient in oxide fuelled reactors is unreliable and the Doppler coefficient assumes importance. The theory for the accurate calculation of this coefficient has been developed over the years. Basic nuclear physics research is involved in obtaining the resonance parameters for the unresolved and resolved resonance regions for the fissile and fertile isotopes. Extensive measurements of the Doppler worth of samples in critical facilities has been made and special theoretical methods developed for the interpretation of the results.

The other challenge in fast reactor physics is the understanding and calculation of the sodium void reactivity effect. The theoretical and experimental investigation of this effect turned out to be difficult and refined methods of calculation had to be developed. A large number of measurements in critical facilities coupled with detailed numerical analysis have made the current situation for the calculation of this effect somewhat satis-factory, at least for the whole core void effect.

Contemporary effort in fast reactor physics has been towards providing as accurate as possible values for the design and safety parameters of large commercial sized LMFBRs.

The work at RRC has been directed towards the generation of a reliable fast reactor physics design capability. For the development of such a capability, programmes have been organised in the following three areas:

- nuclear data evaluation, testing and processing
- reactor theory and design
- analysis of experiments to provide the feedback necessary for the testing and calibration of the nuclear data and the computational methods.

In the area of nuclear data, work is being pursued in the preparation and processing of 'point' neutron cross-section data and fission product data libraries. Numerical experimentation is required to establish the efficiency and accuracy of alternate processing procedures. Also of importance is the study of errors in the basic data and the sensitivity of reactor integral parameters to these uncertainties.

To perform the sophisticated calculations needed to accurately obtain the physics and safety parameters of an LMFBR requires a comprehensive system of accurate and efficient computer codes based on different theoretical approaches and approximations, e.g. diffusion theory, transport theory, collision probability methods, Monte Carlo, perturbation theory, etc. Continuous development work is necessary to develop more efficient and accurate numerical methods and approaches in order to be able to faithfully model the actual core and shield geometries. This becomes especially important for the efforts towards the design of PFBR on account of the lack of critical facility.

To validate the calculational methods and to establish the uncertainty tolerances, it is necessary, to analyse on a continuing basis, experiments performed elsewhere. For PFBR shield design validation, an experimental programme of neutron attenuation and streaming measurements for various shield materials and geometries is planned in the immediate future.

4. FUEL DEVELOPMENT FOR FAST BREEDER REACTOR

The first experimental liquid metal cooled fast breeder reactors had used metallic fuel. The burn-up achievable with metallic fuels was however limited on account of dimensional instability, fuel swelling and fuel cladding metallurgical interaction. Emphasis on high burnup (100,000 MWd/tonne) and high linear power (400 W/ cm) capability fuels in liquid sodium operating temperatures of interest (350 - 550°C) necessitated the development of improved fuels and clad materials. The choice available in 1960s was the oxide fuel based on the rich experience available in all aspects of fuel cycle with oxide fuels in thermal reactors. The choice of cladding material was modified AISI 316 (20 % cold worked) due to its good sodium compatibility, suitable mechanical properties and acceptable irradiation induced change in physical and mechanical properties. Research and development on mixed oxide fuels have, over the years, resulted in optimum specifications for mixed oxide fuels and cladding materials. The advances in reprocessing of high burnup oxide fuel have closed the fuel cycle effectively. Irradiation performance results available on oxide fuels have shown that failure rates in fast breeder reactors are below 1 %. Mixed oxide fuels of present day specifications can achieve burnup of 12 % far exceeding the optimum limit. Such a remarkable behaviour is attributed to the absence of pellet clad interaction stresses which in the case of thermal reactor fuels contribute to failure. Higher temperature and enhanced creep in the fuel and the restraining influence of the strong clad are factors responsible for the low failure rates of fuel pins in fast breeder reactors.

Progress in the area of fuel development is important for fast breeder reactor programmes, to develop advanced fuels which will provide an increased burnup capability, higher specific power capability, lower fuel cycle cost and lower doubling time. Among the more advanced fuels, mixed carbide fuels are the most promising. Even though nitride fuel has shown good irradiation performance, the doubling time is likely to be higher for the nitride as compared with carbide. It has been decided to use plutonium-rich carbide fuel for the Fast Breeder Test Reactor. Experience gained in FBTR in various aspects of fuel cycle using carbide fuel would be valuable in defining the choice of fuel for PFBR.

Fabrication of Pu-rich carbide fuel (Pu 66.5, U 28.5, C 5.0 %)

Plutonium-rich mixed carbide fuel pellets with close control on purity, density, oxygen and nitrogen content, and dimensional accuracy are fabricated by carbothermic route. Fig. 1 shows the details of the flowsheet developed at Trombay. During the carbothermic reduction of the UO_2 - PuO_2 mechanical mixtures, these actinide oxides react independently since the inter-diffusion of UO_2 - PuO_2 is too slow in the temperature range 1400 - 1600°C to allow any rapid formation of a $(U, Pu)O_2$ solid solution. The upper limits of carbothermic reduction temperature are fixed in such a way that no liquid phase formation takes place and plutonium volatilisation is minimum. Studies in Trombay have revealed that it is not possible to prepare relatively oxygen-free plutonium-rich mixed carbide fuel by a single step direct carbothermic reduction of oxides without incurring substantial plutonium volatilisation losses. The furnace temperature and carbon monoxide partial pressure during carbothermic reduction have been optimised by striking a balance between the oxygen content in the carbide end product, the plutonium losses by volatilisation and the reaction rate. The maximum temperature for the synthesis of mixed carbide fuel is accordingly restricted to 1500°C and 1700°C respectively for carbothermic reductions in vacuum and in flowing argon. Thermodynamic data for U-C-O, U-C-N-O, U-C- Pu-C-O, Pu-C-N-O and Pu-C systems have been used as guidelines to optimise fabrication parameters for preparation of (Pu, U)C powders and pellets.

Basic science contributes in a major way to fuel development. Phase diagrams, thermodynamics and kinetic data, surface reactions data, correlation of microstructures with physical and mechanical properties, analytical techniques and modelling for fuel performance are used extensively to develop the fuel and close the fuel cycle effectively on cost-effective basis. Fuel development programme requires generation of data (nuclear, thermodynamic, physical, chemical, metallurgical, etc.,), development of analytical techniques and engineering experience with respect to the various aspects of the fuel cycle.

5. METALLURGY AND MATERIALS SCIENCE

5.1 Areas of basic research for advanced reactors

The viability of any advanced reactor concept as a safe and economical energy system depends on the choice of materials. The materials must perform satisfactorily despite severe environmental conditions to which the various components are subjected. Table I gives a comparison of these conditions for various reactor systems. To ensure this high level of material performance over long periods one has to rely on short-term laboratory tests and techniques dealing on the one hand with materials development and characterisation, and on the other with evaluation and monitoring. The latter is important starting from manufacturing process control, product acceptance and assessment of proper plant assembly, to in-service inspection and continuous monitoring to assure that material components maintain the desired integrity during reactor operation.

To support such a programme, basic research activities fall into three broad groups: (i) materials characterisation, (ii) non-destructive evaluation (NDE) and (iii) materials testing and processing.

Basic research in materials characterisation has played a very important role in reactor development. An overall perspective can be obtained from Table II, where some of the research areas are indicated in relation to the technological applications. The specific areas depend upon the reactor system but broadly fall into the following categories: (i) mechanical bahaviour, (ii) radiation effects, and (iii) chemical and corrosion behaviour. With increasing importance of safety and environmental factors, most pressing problems of research are associated with deformation and fracture of materials; the study of tensile properties, creep and fatigue being the most relevant. Though a fair understanding has been achieved in this area in relating behaviour with structure, interdependence effects like creep-fatigue interaction with the added influence of the environment need extensive research for the design of alloys for superior and dependable performance. Fracture mechanics has also now developed as an important area in basic research, though still highly idealised for application to complex technological materials. The main developments in fracture mechanics have been oriented towards attempts to characterise the elastic plastic fracture toughness, correlation of fracture toughness parameters with crack growth in creep, fatigue and mixed loading conditions. An important area is the life prediction or the determination of failure conditions for complex structures, and simple toughness evaluation tests for quality control. Another area which has not attracted the kind of attention it deserves, is probabilistic fracture mechanics, since distribution in toughness values and interacting cracks in a spectrum of load and temperature cycles are realities.

Radiation introduces an important parameter since due to damage, one introduces additional defects which influence the structure-sensitive mechanical properties. In many cases, irradiation leads to phenomena which are not encountered in normal thermo-mechanical treatments, like irradiation enhanced creep, void swelling, production of new phases, segregation and precipitation effects. Also effects like helium embrittlement in fast reactors (and erosion in fusion reactors) are direct consequences of radiation damage. The study of all these properties in radiation environments has gained special significance and created the need for understanding the basic radiation damage processes. Basic research in these areas naturally requires good radiation sources such as material testing fast flux reactors and accelerators. Table III outlines the scope of such facilities. As an example, Table IV shows how basic research in void swelling has led to new engineering materials (with low propensity to swelling) which are finding applications in advanced fast reactor systems.

Another area of considerable concern where basic research is important for advanced reactors is corrosion. Due to the high temperature gradients encountered and the non-aqueous mediums in which the structures have to operate, mass transfer of selected elements takes place. Structures most commonly affected are the fuel cladding, reactor piping and heat exchanger surfaces. In sodium-cooled fast reactor systems, where stainless steels are usually employed as core structural materials, the mass transfer characteristics in sodium of carbon and nitrogen are particularly important since these influence the mechanical properties. Self-welding between contacting metal surfaces in sodium, cavitation damage, compatibility of sodium with mixed oxide and carbide fuel materials and sodium effects on shielding and neutron absorbers, brazing alloy and bearing materials are some of the other important areas. Laboratory research programmes to study diffusion in a severe temperature gradient, carbon and Cr diffusion in Fe-Ni-Cr alloys and grain boundary penetration by alkali oxides have also made valuable contributions. Aqueous corrosion due to high temperature oxidation in steam affects the integrity of steam generator tubes. Steam generators and fuel cladding in water cooled reactors are susceptible to significant pitting crevice attack. Condenser, steam generator and turbines are subjected to erosion-corrosion damage. Stress corrosion and hydrogen embrittlement effects occur in turbines, steam generators, condensers and nuclear components like pressure tubes in water reactor systems.

The scope for NDE in materials research includes the traditional methods of detection and analysis of flaws using ultrasonic, electromagnetic and radiography techniques and non-traditional techniques like acoustic emission and laser holography. High priority has to be placed on basic research to improve the understanding of the interaction of the probing energy radiation with different characteristics of defects, like the developments in signal processing and imaging techniques. There is also need to develop better

NDE techniques for ceramics and brittle materials.

Another area of high priority is the development of surface sensitive chemical and phase analysis instrumentation, since corrosion, embrittlement, chemical segregation, coating degradation, concrete curing and sealing are some of the often encountered problems in reactor systems. These require quantitative chemical and phase information about the surface, the bulk material and the effect of chemical gradients through layers. Available non-destructive techniques are still inadequate for such analysis.

Of all the methods of materials processing, welding is one of the most widely used in advanced reactor systems; yet from a fundamental point of view, it remains one of the least understood. Therefore, welding and weld microstructures of austenite stainless steels have been a subject of considerable study. Depending on the composition, the 300 series alloys solidify either as primary ferrite or austenite. When one considers the eutectic trough in the ternary diagram, Cr rich side of the eutectic liquid solidifies as primary dendrite. The solidification process is associated with non-uniform composition in the microscopic scale. This has a far reaching effect in the subsequent elevated temperature treatment (such as high temperature application, post weld treatment, etc), and leads to possibilities of formation of stable phases like the sigma, chi, μ and other carbides, often with deleterious consequence. It was recognised early in the welding of stainless steel that some amount of retained ferrite is beneficial especially in preventing the tendency to hot cracking. The exact mechanism by which this is achieved is still an unresolved subject. One explanation offered is the scavenging action of the ferrite phase for the deleterious elements like P. Another is the retention of these elements in favourable locations as e.g. grain edges rather than grain faces by alteration of the interfacial energies. Hence, for engineering use, an accepted level of ferrite was specified and successful welds were achieved. On the other hand, thermal instability of the ferrite phase and the associated solute segregation effects lead to problems of embrittlement, and degradation due to corrosion, thus placing an upper limit on allowable ferrite in practice. In this context, a need was felt for an absolute method of estimating ferrite in the weld so that technologically feasible methods could be standardised by comparison. A systematic study of the electrochemical nature of the austenite, ferrite and other phases in the stainless steel was undertaken which led to a quantitative estimation method comprising of an electrochemical and chemical separation procedure.

Based-on the experience gained in using conventional welding methods, two other areas of advanced joining techniques require development. One is the joining of heavier sections, perhaps using methods like electron beam welding. The second involves joining of difficult-to-weld materials like ceramics, refractory materials and composites.

5.2 Typical Examples from Metallurgical Investigations

In the previous section, areas of basic research relevant to reactor systems have been indicated. In this section, some typical examples will be given from various fields, covering the scope of activities discussed earlier.

Irradiation Effects

Nickel-based alloys are possible structural materials in fast reactors. Two alloys, PE 16 and Nimonic 90, strengthened by precipitation reactions, have good swelling characteristics. These alloys are however susceptable to He embrittlement due to the high Ni concentrations. Thermomechanical treatments have been developed for PE 16 to produce uniform distribution of γ' and fine equiaxed TiC precipitates. It is expected that such a distribution of the carbide phase would improve the post-irradiation ductility due to trapping of He by carbides. Fig. 2 shows the effect of irradiation on precipitates in Nimonic 90 when the precipitates have been broken. The irradiation was done using low energy He ions (100 KeV) to a dose of 3×10^{17} He / cm^2. Such low energy beams are unsuitable for producing samples for mechanical testing. Simulation studies can however be carried out by implanting He at higher energies ($\sim$ 35 MeV) uniformly in 200 μm thick samples that are suitable for mechanical testing. Such metallurgical investigations have been initiated in recent years, and can be very effectively employed to study effects like He trapping by carbides in stainless steels. Irradiation creep data can be obtained from both reactors and cyclotrons and compared. Metallurgical investigations of this nature are of recent origin and would prove extremely useful for screening and testing of materials. Simulation of void swelling has proved extremely successful in alloy screening and detailed theoretical models have led to the understanding of the differences between reactor data and simulation data obtained from HVEM and accelerator studies. Such simulation studies are now extended to more complex situations of swelling where applied stress and irradiation creep occur simultaneously. Alloying elements in stainless steels have proved to be one of the important ways of controlling swelling. Another important metallurgical parameter is the ductility and impact toughness under irradiation. The nil ductility transition temperature NDTT of any material should remain nearly 40^{o} C below the operating temperature of the component. The variation of NDTT with irradiation dose and methods of overcoming the deleterious consequences is an important area of study (Fig.3).

Structure - Property Correlation

The importance of structure-property correlation will be illustrated by using one structural entity, viz. grain boundary. A large volume of basic research has gone in describing the grain boundaries from which follow many of their properties like mobility, diffusion behaviour, etc. The change in tensile ductility as a function of grain size can be clearly linked to the famous Hall-Petch relation. The influence extends to high temperatures where creep is a dominant phenomenon. A recent creep study in 316 SS recognises the fact that a relatively lower temperature g.b contribution to creep strength is significant. At higher temperatures, this contribution was absent. Detailed substructural studies were used to explain the difference in behaviour. Such an understanding helped in choosing the right thermomechanical treatment for the clad tubes from among various possibilities.

Another effect of grain boundaries is in governing the corrosion behaviour. For example, heat treatment in the range of 500–650^{o} renders most stainless steels 'sensitized' with Cr rich carbides forming at the grain boundaries. This is usually associated with a depletion of Cr in the adjoining region and renders the material susceptible to a localised corrosion attack. A phenomenon such as this places severe restriction on the fabrication methods and acceptable conditions of use of materials.

In a recent study at RRC, it has been shown that grain boundaries play an active role in determining the low cycle fatigue strength of stainless steels. Similar to tensile strength, lowering of grain size increases fatigue strength. Every effort is being made to understand the underlying mechanisms in this case.

There are other structural entities that have strong influence on properties, (e.g. dislocation and dislocation substructure, second phase particles) and continued research is on to explain the interplay of structure and properties as comprehensively as possible. An example worth mentioning in this regard is a recent study on the crevice corrosion attack on stainless steel where the influence of various microstructural variables including texture were examined in detail.

6. CHEMISTRY, RADIOCHEMISTRY AND FUEL REPROCESSING

6.1 Fuel Chemistry

Studies on the chemistry of fuels are aimed at working out specifications for a fuel element which has high power rating and can withstand high burn-up with minimum fuel-clad chemical interactions.

Thermodynamic parameters and phase relationships in fuel materials have to be studied in great detail to specify fuel composition. The fuel behaviour is complicated by the presence of fission products which are formed during irradiation of the fuel. New compounds are formed which affect the fuel clad interaction and can give problems during dissolution. In the case of carbides, the fission products pose additional problems in that there is a lot of uncertainties in the fraction of carbon that will be tied up by fission products. Because of this, the initial C/M ratio of the fuel is specified based on assumptions of chemical states of fission products. The oxygen and nitrogen impurities in carbide fuels also affect the fuel behaviour and, therefore, understanding the effect of these impurities is essential to arrive at specification limits.

Thus, a good deal of thermodynamic information has to be generated to understand and predict the behaviour of fuel during irradiation. This is true, particularly, in the case of advanced fuels where very little information is available. Even for mixed oxides, many gaps are still to be filled.

Under the influence of temperature gradient, elements constituting the fuel and fission products redistribute. Both solid state as well as vapour phase transport processes are responsible for migration. Data on vapour pressures, diffusion parameters and thermodynamic quantities are necessary to develop a suitable model for predicting the extent of redistribution. The model has to be calibrated against experimental data, first from out-of-pile studies and later from post-irradiation examination. Such studies on chemical transport will help in assessing the extent of plutonium segregation in the centre, the possibility of fuel-clad chemical interactions, etc.

The most important factors deciding the linear power rating are thermal conductivity and melting point of the fuel. Thermal conductivity data have to be generated as a function of plutonium concentration, impurity levels, stoichiometry, porosity and burnup.

The above studies concern the chemical behaviour of the fuel under normal operating conditions. However, to predict the behaviour in accident situations, some of the studies have to be extended to very high temperatures. The future programme in chemistry thus includes development of models as well as the experimental facilities required for such studies.

6.2 Coolant Chemistry

Chemistry of the sodium coolant is another important area of research in our fast reactor development programme. The aspects of sodium chemistry that need detailed investigation are : i) behaviour and chemical state of impurities in sodium, (ii) chemical interaction between sodium and clad as well as sodium and fuel, and (iii) transport of radionuclides in sodium circuits.

While pure sodium is an excellent coolant, impurities present in sodium even in ppm levels can affect reactor life and operational safety. A thorough understanding of the behaviour of impurities is thus essential. Chemical characterization of the coolant should be carried out before charging and during reactor operation. This necessitates development of methods for accurate chemical analysis of the coolant as well as continuous monitoring. The monitors for impurities such as carbon, oxygen and hydrogen have been developed in this laboratory and are being tested in sodium loops. These monitors will help in detecting air, oil and steam leaks into sodium circuits. Studies with carbon meter will further help in establishing the kinetics and the species responsible for carburization and decarburization phenomena in sodium -stainless steel systems.

In the primary sodium circuit, radionuclides arising from activated structural materials and failed fuel pins are transported to different regions affecting the operational safety. Monitoring of these nuclides will help in detecting fuel pin failures. An understanding of the basic processes involved in radionuclide transport will be of use in devising means of minimising it.

Operation of the reactor with a failed fuel pin necessitates a clear understanding of the interaction between fuel and coolant. Interaction between clad and coolant in the presence of dissolved impurities, especially oxygen and carbon, is a problem unique to fast reactors and can result in the formation of compounds such as $NaCrO_2$. Basic thermodynamic data necessary for understanding fuel-coolant and clad-coolant interactions are being generated. Studies on compounds such as $NaCrO_2$ and Na_3UO_4 have been taken up. The data on such compounds will help us arrive at threshold oxygen concentration in sodium for the interactions.

6.3 Fuel Reprocessing

For the success of the breeder reactor system using advanced fuel, it is vital to establish schemes to reprocess fuel and blanket with high efficiency and short cycle time and thus close the fuel cycle. Fuels discharged from these reactors have characteristics different from those of thermal reactors mainly because of their high Pu content, high burnup level and chemical composition. Hence, direct application of the popular purex process, used for reprocessing of fuel from thermal reactors adopting chemical processes such as direct dissolution of fuel in nitric acid and solvent extraction processes with 30% TBP for recovery and purification of Pu and U, meets with severe constraints. Thus R&D studies have been initiated in several areas of process chemistry related to FBR fuel reprocessing.

Sodium associated with the fuel can lead to an explosive reaction and a process to deactivate sodium with argon, steam mixture is being studied. Mixed carbide fuels of Pu and U, particularly with high Pu content, have not so far been reprocessed even on a pilot plant scale. Direct dissolution of this fuel in nitric acid yields brown organic species, mostly oxalic and meletic acid. These organic species have to be destroyed to prevent severe emulsification and loss of heavy metals because of complexing with these acids during solvent extraction. Electrolytic oxidation of these acids during solvent extraction appears to be promising. Pyrohydrolysis of carbide to their oxide with argon, steam mixture at 700 to 750°C and direct oxidation of carbide to their oxides are also in an experimental stage as alternate processes. Radioactive iodine existing as different chemical species in the off gas streams have to be contained and prevented from release to the environment. This has necessitated study of processes such as scrubbing using mercuric nitrate or concentrated nitric acid, absorption on molecular sieves and silver impregnated solid absorbants. High Pu content warrants studies in the solvent extraction process using TBP. These include collection of relevant data related to solvent extraction equilibrium in U-Pu nitric acid-TBP system, study of phenomena of formation of Pu-rich third-phase (than can impair the stability of operation) and to choose a process condition to avoid them. High Pu content needs processes like electrolytic reduction of Pu alternate to the current processes using chemical reductants such as ferrous sulphamate and uranium nitrate for separation of U and Pu to avoid high salt content.

High fission product content in the process solution poses a threat of radiation damage to the solvent during solvent extraction leading to its degradation to harmful products which complex Pu and lead to its loss. Efficient techniques to wash these degradation products of the solvents are also being developed. In addition, search for alternate solvents that have better radiation resistance and less probability for formation of Pu rich third phase is being pursued. Solvents such as trihexyl phosphate, diamine, hold promise for the future. Use of chemical poisons such as salts of gadolinium and boron is to be studied for use as soluble poison to avoid conditions of nuclear criticality in areas where protection cannot be offered by eversafe geometry or concentration.

Non-aqueous methods of reprocessing fuels are attractive from the point of view of reducing the number of process steps, avoiding the problem of radiation damage to solvent, possibility of reduction of fuel cycle time, and reduction in waste volume. Some of the processes are being pursued as future alternatives to the present modified purex process.

7. PHYSICS OF LMFBR SAFETY

The safety of a fast reactor is ensured at three different levels:

a) the design and construction of an inherently safe system;

b) incorporation of diverse and redundant protection systems to act in the event of off-normal events;

c) design and construction of the reactor vessel and containment building such that a hypothetical accident, occuring in spite of the first and second level safety measures, causes no hazard to the public or environment.

Considerable physics effort is required in designing an inherently stable reactor and in estimating the severity of hypothetical accidents. The dynamic stability of a fast reactor core is governed by the prompt neutron lifetime, the delayed neutron parameters and reactivity feedback coefficients associated with the Doppler effect and expansion of sodium and structural materials. Accurate evaluation of these dynamics parameters is important and depends on the basic nuclear and thermal data as well as realistic heat transfer modelling of the core subassemblies and structures.

The early fast reactors were small and it was possible to build strong enough vessels and containment buildings to withstand all postulated accidents and contain the reactivity. For the larger reactors, it is important to re-assess this question and study the accident sequence in detail. This requires investigation of the precise nature and sequence of the various phenomena occurring in the reactor during an accident (Fig.4).

It is convenient to consider the accident sequence in three different phases - pre-disassembly, disassembly and mechanical work - as the physical phenomena involved are different.

The pre-disassembly phase involves the study of core neutron kinetic, mechanical and thermal behaviour upto the point of loss of subassembly geometry. Pheoomena needed to be considered are hydraulic transients, sodium boiling, fuel pin failure mechanics, effects of fission gas release on pin cooling, fuel washout after clad failure, clad and fuel motion under meltdown conditions, etc.

Study of the details of the basic heat transfer between molten fuel and coolant and the phenomenon of vapour explosions is an important area of research.

In the disassembly phase, the fuel attains very high temperatures and fuel vapour pressure buildup causes the core to disrupt, with physical movement of the fuel from high pressure to lower pressure regions. Equations of state of core materials for a wide range of temperature are required and the complete data in this respect are not available. Studies on transient vapour buildup during adiabatic heating of fuel are also important.

In the last phase of the accident, the core disruption leads to mechanical damage of the reactor vessel and other structures. Investigations in shock-structure interactions is of importance in this context.

At RRC, considerable emphasis has been placed on basic theoretical and experimental studies in all the phenomena of importance to understanding the course and effects of core disassembly accidents.

8. CONCLUSIONS

A survey of the areas of basic scientific research in the development of LMFBR technology has been presented above with particular reference to the programmes of the Reactor Research Centre. While it is too early to fully assess the fallout and spin-offs to be obtained from this research, it is clear that there will be considerable and clear-cut developments in the physics, chemistry and metallurgy of special LMFBR materials and in the physics and safety of fast reactor cores. The research, especially in areas of neutron interactions, blanket neutronics, behaviour of materials under intense irradiation, liquid metal chemistry, metallurgy of steels and other alloys, etc., will be of relevance for the fusion reactor system of the future.

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TABLE - I

TYPICAL OPERATIONAL CONDITIONS FOR REACTOR SYSTEMS
(Material Considerations)

PARAMETER	UNIT	THERMAL HEAVY WATER	FAST BREEDERS	FUSION REACTORS
TEMPERATURE	^oC	300	400-500	300-500
DAMAGE RATES	$dpas^{-1}$	10^{-8}	10^{-6}	$(10^{-6})^a$ $(10\text{-}10^3)^b$
TOTAL DAMAGE	dpa/yr	< .1	50-100	10-100
HELIUM PRODUCTION	appm/yr	< 1(Zr)	5-50 (SS)	100 (SS) - 200 (Al)
STRESS LEVELS	MPa	10-50	60-120	60-200
HELIUM/DAMAGE RATIO	appm/dpa	60 (SS)	15 (316 SS)	< 1 (316 SS)
LIMITING FACTOR FOR BURN UP		Xe Poisoning	Swelling Distortions	First Wall Damage by He/ions/n
MATERIAL FACTORS		Irradiation Creep - Coolant Channels	Swelling Embrittlement Sub-assemblies	Erosion of First Wall

a. Controlled Thermonuclear Reactors

b. Inertial Confinement Fusion Reactors (pulsed μs)

TABLE - II

BASIC AREAS OF RESEARCH FOR REACTOR SYSTEMS

AREAS OF RESEARCH	TECHNIQUES	MATERIALS	TECHNOLOGICAL CONCERN
DIFFUSION (Radiation Environment)	TRACER SIMS MOSSBAUER INTERNAL FRICTION	Fe-Ni-Cr ALLOYS Zr ALLOYS UO_2 PuO_2 UC, PuC	FUEL AND CLAD STABILITY
He IN METALS PPT., DIFF.etc.	SEM/TEM DESORPTION POSITRON ANN. NUCL. SCATT.	NIMONIC ALLOYS PE16 FERRITIC STEEL Ti-STAINLESS STEEL	EMBRITTLEMENT OF SUBASSEMBLIES GRID PLATE Etc.
VOID FORMATION	TEM DENSITOMETRY SIMULATION	Ti-STAINLESS STEELS Fe-Ni-Cr ALLOYS	SUBASSEMBLY BOWING/ DIMENSIONAL STABILITY
DEFORMATION	TENSILE, CREEP, DUCTILITY, FATIGUE, IMPACT TESTS	Fe-Ni-Cr ALLOYS STAINLESS STEELS	MATERIALS SELECTION PROCESSING AND FABRICATION INSERVICE LIFE
PHASE STABILITY	SEM/TEM, X-RAY NEUTRON SCATTERING POSITRON ANN.	γ'-NIMONIC ALLOYS MX-STAINLESS STEEL LAVES PHASES	DUCTILITY OF CORE COMPONENTS/COOLANT CIRCUIT
CORROSION AQUEOUS AND NON-AQUEOUS	POLARIZATION ESCA/AES SEM MICROPROBE	STAINLESS STEELS LOW AND HIGH ALLOY FERRITIC STEELS	CORE AND PRIMARY COOLANT CIRCUITS/HEAT EXCH./STEAM GENERATORS/TURBINE/FUEL-CLAD-COOLANT INTERACTION
SUPERCONDUCTIVITY T_c, J_c, H_c	ELECTRICAL RESISTIVITY	Nb_3Sn NbTi	SUPERCONDUCTING MAGNETS/FUSION REACTORS

TABLE - III

ACCELERATOR BASED IRRADIATION FACILITIES FOR REACTOR MATERIAL STUDIES

ACCELERATORS	YEAR/INDIA	BEAM	ENERGY CURRENT	BASIC INVESTIGATIONS	CHARACTERISTICS	
LOW ENERGY LIGHT IONS	1979	H d He	150 keV	BLISTERING/EROSION/ He PPT. ACTIVE WASTE STORAGE - OXIDE GLASSES	RANGE DAMAGE SEM/TEM	1000 A 10^{-3}dpas^{-1}
LOW ENERGY HEAVY IONS	1984-85	Al Ni	400 keV 10 μA	LIGHT METALS-Al SWELLING ENHANCED DIFF. PHASE STABILITY	RANGE DAMAGE SEM/TEM	100-1000 A 10^{-3}dpas^{-1}
LIGHT ION TANDEM/ VAN DE GRAAFF	1962 1982 1984-85	H d He	4 MeV 10 μA	RADIATION ENHANCED INTER-DIFFUSION DEFECT	RANGE DAMAGE	5 μm 10^{-6}dpas^{-1}
LIGHT ION MEDIUM ENERGY	1983	H d He	100 MeV 50 μA	IRRADIATION CREEP He-EMBRITTIEMENT FATIGUE	RANGE DAMAGE	200 μm 10^{-6} dpas^{-1}
HEAVY ION MEDIUM ENERGY		Al Ni Ta	10 MeV 5 μA	VOID SWELLING PHASE STABILITY	RANGE DAMAGE TEM	1000 A 10^{-3}dpss^{-1}
HIGH ENERGY LIGHT IONS		H	600 MeV 2 μA	He in METALS (by Nucl.Reac.) SWELLING	RANGE DAMAGE TEM	1000 μm 10^{-6}dpas^{-1}
HIGH VOLTAGE MICROSCOPE		e	2 MeV	VOID SWELLING PHASE STABILITY	RANGE DAMAGE HVEM	1000 μm 10^{-3}dpas^{-1}
ELECTRON		e	2 MeV 100 μA	BASIC POINT DEFECT STUDIES DAMAGE PROCESSES	RANGE DAMAGE X-RAY,NEUTRON DIFFRACTION	100 μm 10^{-7}dpas^{-1}

TABLE - IV

BASIC RESEARCH IN SWELLING - IMPACT ON CORE MATERIAL DEVELOPMENT

YEAR	RESEARCH DEVELOPMENT	MATERIAL DEVELOPMENT	REACTORS (FAST)
			CLEMENTINE/EBR I/ DOUNREY/EBR II ENRICO FERMI (Annealed, V Alloys)
1965	SWELLING DISCOVERED	SOLUTION ANNEALED STAINLESS STEEL SWELLING > 15% 100 dpa	RAPSODIE Annealed SS
1970	SIMULATION METHODS BY ACCEL./HVEM DEVELOPED		
	RATE THEORIES		
	EXTENSIVE STUDIES COLD WORK/MICRO-STRUCTURE AS VARIABLES		
1975	THEORETICAL CORRELATION ACCEL/HVEM/ REACTOR DATA	COLD WORK 20% STAINLESS STEEL SWELLING 10% 100 dpa	PHOENIX Annealed 20% CW SS
			PFR PE16/20% CW SS
	SIMULATION VOIDS IN ALLOYS WITH IMPURITY TRAPS Si/Ti		
1980	EFFECT OF PHASE STABILITY ON SWELLING RATE	Ti STABILIZED STAINLESS STEEL SWELL. <5% 100 dpa	SUPER PHOENIX Ti Stabilized 316 SS
1985	EFFECT OF INHOMOGENEOUS GROWTH, PULSING, HIGH dpa RATES		FBTR 20% CW SS
			CDFR PFBR 500 Ti Stabilized 316 SS

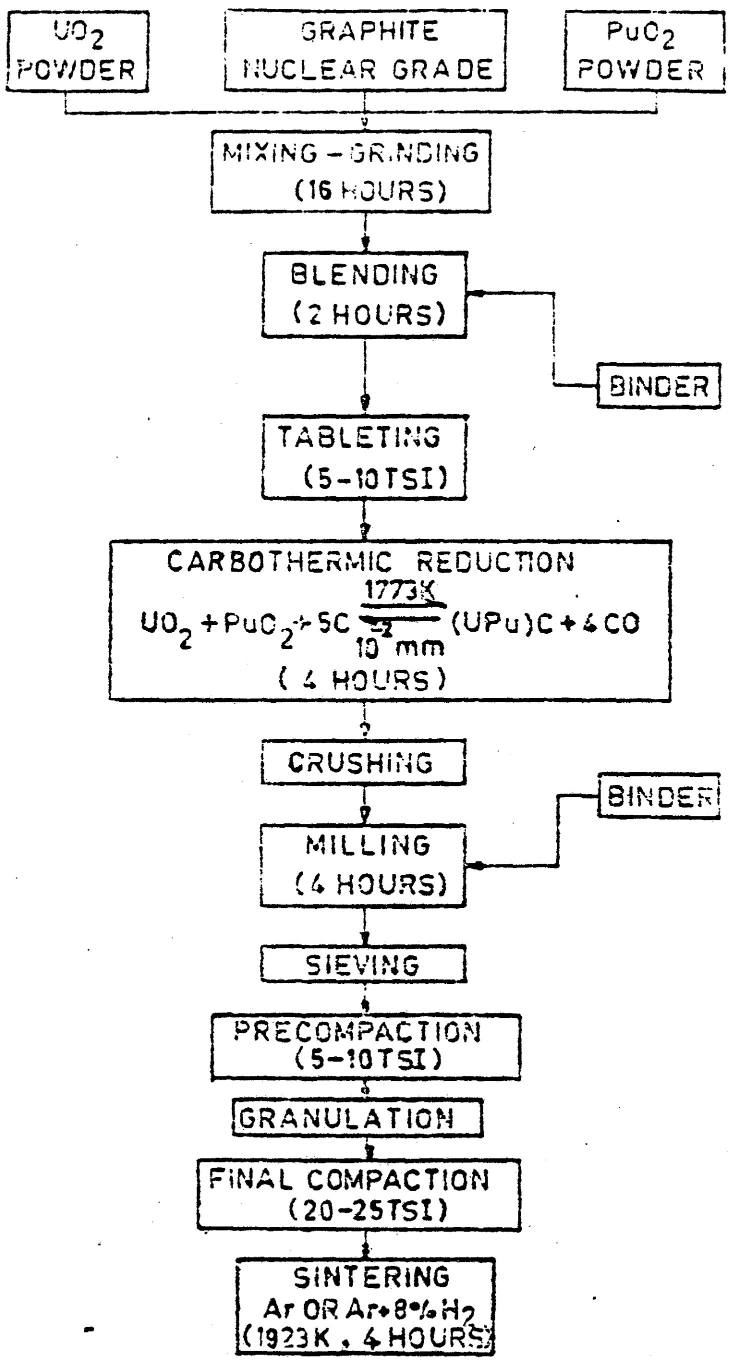
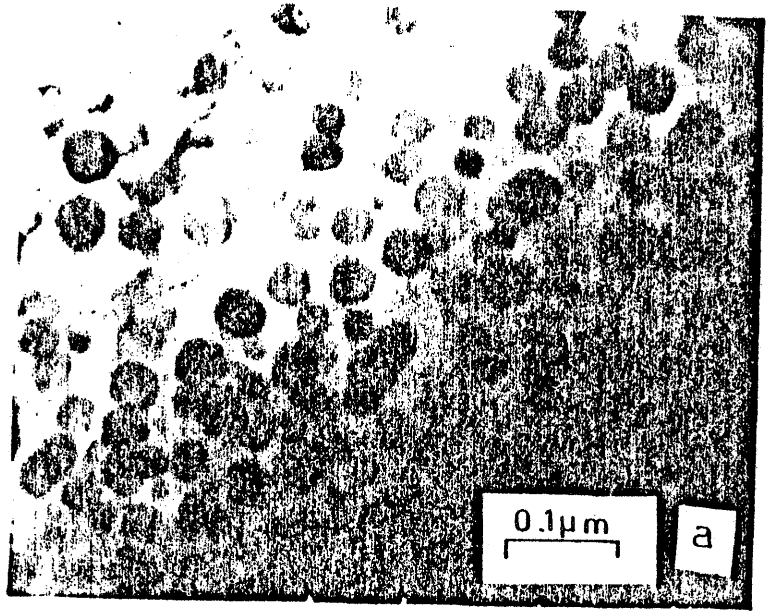
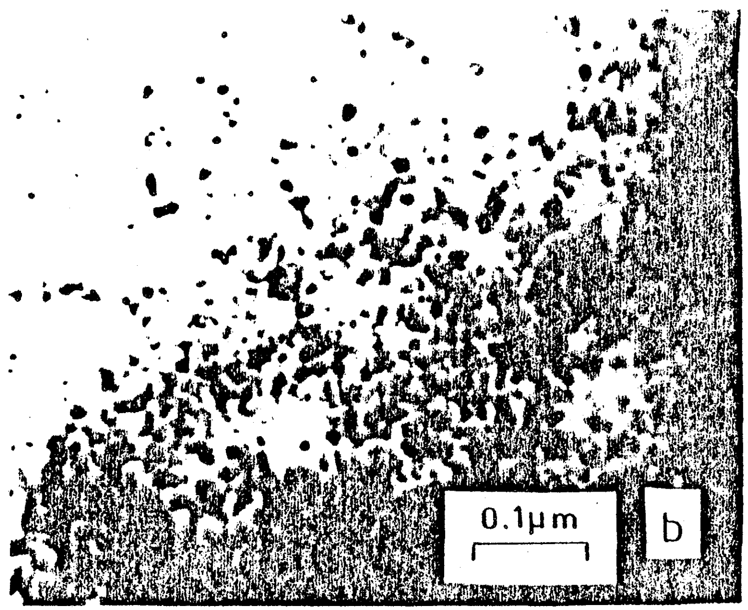


FIG.1. FLOWSHEET OF FABRICATION OF (UPu) CARBIDE FROM UO_2 AND PuO_2



(a) UNIRRADIATED



(b) DOSE : 3×10^{17} He/cm^2

FIG.2. γ'-PRECIPITATES IN NIMONIC 90 UNDER HELIUM ION IRRADIATION

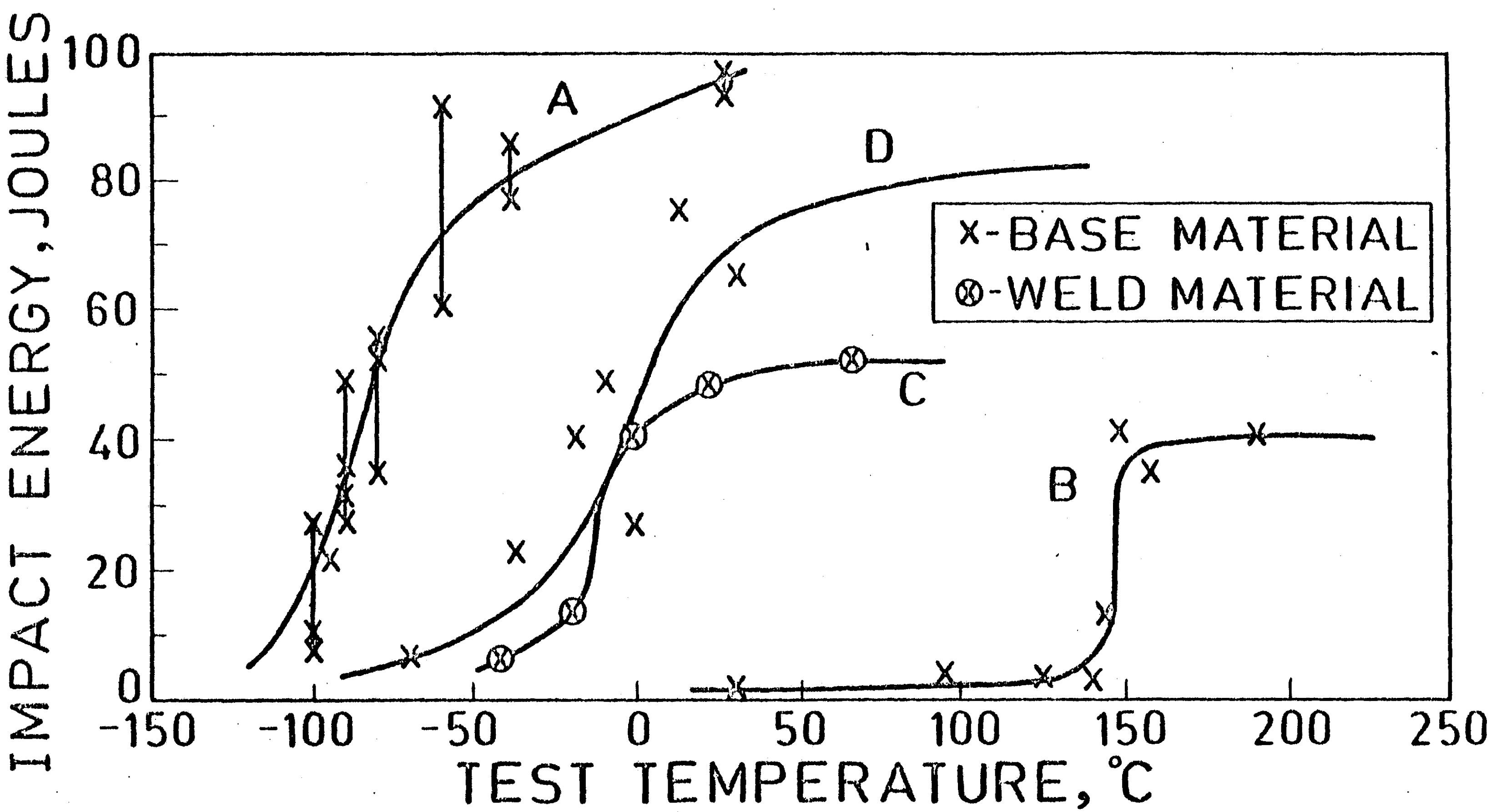


Fig. 3 Impact energy vs temperature curves for ASTM A 203 Grade D steel;
A = Unirradiated; B = Irradiated to a fluence of 3.5×10^{19} n.cm^{-2}; C = Irradiated to a fluence of 5×10^{18} n.cm^{-2}; D = Annealed at 300°C for 15 days after irradiation to a fluence of 3.5×10^{19} n.cm^{-2}

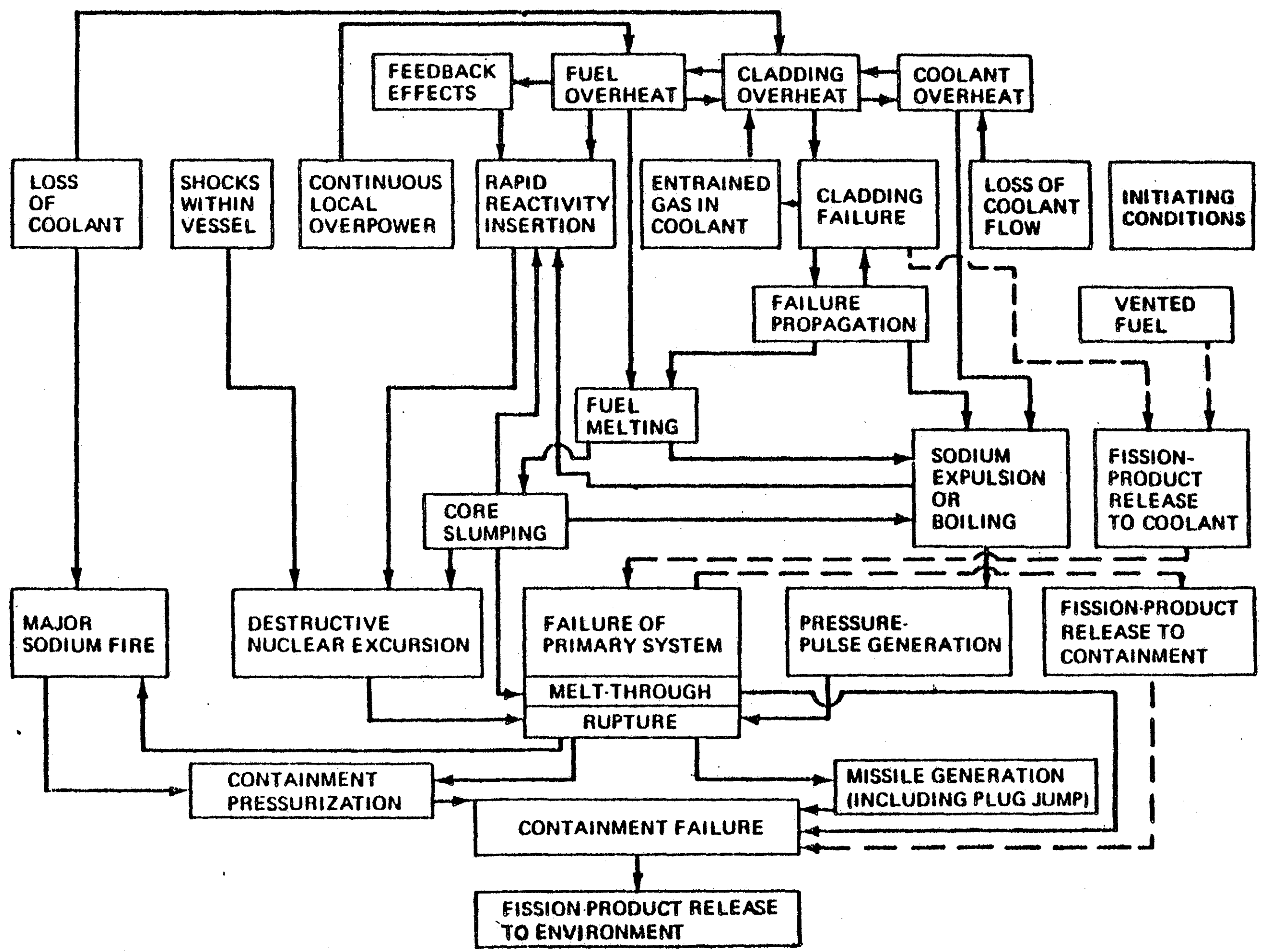


FIG ·4· TYPICAL ACCIDENT SEQUENCE DIAGRAM.

Appendix 14

SIXTH RCA WORKING GROUP MEETING

COUNTRY STATEMENTS

SIXTH RCA WORKING GROUP MEETING

COUNTRY STATEMENT - AUSTRALIA

This is the seventh year in which Australia has actively participated in the RCA. At the present time, the contribution to the project on "On-stream Analysis and Control of Mineral Concentrators" constitutes Australia's total direct financial contribution to the RCA. This contribution is a significant one, amounting to $A655,000 over a five year period. Apart from its support for the Isotope Hydrology project, Australia has been actively involved in other RCA projects through the provision of experts and facilities and in hosting meetings and courses. Australia will consider carefully and sympathetically further requests for assistance in kind.

However in assessing any requests for further commitments to specific projects, account must be taken of the current review of Australia's aid program being undertaken by the Australian Government. In this context, it is noted that the documentation for this meeting refers to Australia's interest in Phase II of the Regional Project on Food Irradiation and expresses the hope that a decision might be advised at this meeting. Unfortunately that has not proved possible. Australia remains interested in participation in the Project, however, believes that it possesses the necessary expertise and facilities to make a substantial contribution and has the matter under active consideration at present.

SIXTH RCA WORKING GROUP MEETING

COUNTRY STATEMENT - BANGLADESH

Bangladesh has been actively participating in most of the RCA projects including UNDP Industrial Project since their inception with the aim to increase Regional Co-operation in the peaceful application of Nuclear Science and Technology. Bangladesh had the previlage to host the 5th RCA Working Group Meeting in Dhaka. It is a pleasure for us to be participating in this 6th RCA Working Group Meeting, which is being held in our neighbouring country, India.

The current status of Bangladesh activities in some of the RCA projects are summarised below:-

1. FOOD IRRADIATION

At the out set, I would like to announce with pleasure that Bangladesh in Dec,1983, on the recommendation of a National expert Committee formed for this purpose by the Bangladesh Standard Institute(BDSI), officially adopted General Standard for Irradiated Foods and the Code of Practice for Operation of Irradiation Facilities as was recommended by the Codex Alimentarius Commission to the Member States. The latest revised version is now being incorporated in the final draft of the BDSI.

In Food Irradiation, 2 projects namely,"Pilot Scale Studies on the Irradiation of Bangladesh Onions" and "Time-temperature tolerance and packaging studies of irradiated dried fish" are being carried out at the Institute of Food and Radiation Biology, while a 3rd project has been started in this Institute on the "Insect disinfestation of pulses, oil-seeds and tobacco leaves by irradiation". In case of onions, bulk irradiation and storage trial in the harvesting season of 1981-82 and 1982-83 were undertaken to evaluate ideal storage conditions of irradiated(50-70 Gray) onions for one season storage. Effective inhibition of sprouting by radiation was achieved. Storage of irradiated onions at ambient conditions (22-32°C and 70-90% R.H.) while spread on elevated platforms and in net bags with adequate ventillation and air flow system, has been found to be suitable in minimizing storage losses. Radiation preservation has been observed technically feasible and economically adaptable.

In dried fish, it was established that irradiated dried fish (upto 1.0 kGy) could be stored at ambient temperature ($30\pm2^{\circ}C$) in Bangladesh provided that the moisture content is below 15%. In search of suitable packaging materials available in Bangladesh to check re-infestation of the product,detailed insect penetration studies of different packaging materials were made. With the exception of polypropyline lined with kraft paper(PPK) all packaging materials checked the re-infestation of insects. This experiment was partly conducted in the storage house of the traders. Similar results both in the laboratory and in the commercial storage were obtained. Organoleptic evaluation was also made. All the consumers were willing to buy the irradiated dried fish if available in the market. The unirradiated sample (control) was totally unacceptable and had to be discarded. Plywood boxes proved an alternate to carton boxes for export.

Semi-commercial studies for storage and transportation in Carton boxes and plywood boxes will be repeated in the following season.

After the legal clearance of irradiated food by the Govt., we plan in coming years to conduct open marketing and consumers acceptance studies of onions, dried fish and other irradiated foods on semi-commercial scale.

During December 1982, a National Seminar on Food Preservation by Radiation was held in Dhaka. Besides local speakers, 3 experts from IAEA and India participated in the seminar which was largely attended by local traders, private entrepreneurs,and public media. Subsequently in Sept. 1983 a team for RPFI visited Dhaka to assess the commercial potential of food irradiation in Bangladesh. After all these motivational activities, the responses in commercial circles have been so encouraging that at least 3/4 Groups of Industries are now interested to set up Commercial irradiators in various parts in Bangladesh. BAEC is already negotiating with one of them to float a Joint Venture Company for the establishment of a purely commercial multipurpose Irradiator near Dhaka.

We are also happy to announce that under its Technical Assistance programme of 1984, IAEA has kindly offered to supply from USSR a multipurpose Demonstration Irradiator to Bangladesh which we propose to locate at the Atomic Energy Research Establishment at Savar. A two-man team of IAEA Staff member is now in Dhaka to finalize the design specifications and draft agreement for consideration of Bangladesh Govt. When materialized, we shall be glad to offer these facilities for the use of RCA member states in the frame work of a RCA Regional Centre for Food Irradiation as was proposed in the last (5th) RCA Working Group Meeting in Dhaka, on agreed terms and conditions.

2. RADIATION STERILIZATION OF MEDICAL PRODUCTS

Both R&D and promotional activities on radiation sterilization of local medical products progressed satisfactorily during the year with more and newer types of medical products enlisting for radiation sterilization services at BAEC gamma facility. These new products included delivery kits, pharmaceutical containers, re-useable plastic petridishes, etc.

The IAEA expert's report on Radiation Sterilization of Pharmaceuticals in Bangladesh was made available to Bangladesh government last year. Following the recommendation of the expert, government has taken necessary steps for setting up a pilot scale irradiator for sterilization of medical supplies in the country. Meanwhile, a Code of Practice for Sterilization of Medical Products has been drafted which is now under circulation for opinion of the interested quarters.

3. NUCLEAR MEDICINE

In Bangladesh, the nuclear medicine activities are increasing gradually in Six Nuclear Medicine Centres in different parts of the country, in collaboration with the Health Services for diagnosis and treatment of diseases by nuclear medicine techniques. Following programmes are being undertaken under the RCA programme:-

a) Bangladesh organized a national workshop on " Quality Control in Nuclear Medicine Instrumentation" in collaboration with the IAEA which was held in the Institute of Nuclear Medicine from 14-17 November,1983. There were 20 participants consisting of the physicians, physicists and electronic personnels who attended the workshop. Several quality control equipment are available in the country and more are being procured.

b) Bangladesh has recently entered into the coordinated research programme on "Nuclear Medicine Techniques in Tropical and Parasitic Diseases" and the Institute of Nuclear Medicine has taken up the research contract with the IAEA from Sept.1983 on "radioimmunomatric method for determination of antibody in malaria and filariasis".

c) Institute of Nuclear Medicine has been undertaking research work in collaboration with the IAEA and WHO since its inception in 1981 for evaluation of liver in patients suffering from cirrhosis, haepatisis and malignant diseases. Iodine deficiency is a common disease in Bangladesh and the works are under way in all the Nuclear Medicine Centres and the Institute of Nuclear Medicine. The Institute of Nuclear Medicine has also been setting up a central RIA laboratory for determination of thyroid hormones and to work as a national standard laboratory.

d) Future programme in Nuclear Medicine:

i) Improvement of cancer therapy:

As proposed in the last RCA meeting in Dhaka, Bangladesh Atomic Energy Commission is planning to set-up a Centre for improvement of cancer therapy by modern teletherapy and LINAC.

ii) Nuclear Cardiology:

Institute of Nuclear Medicine, in collaboration with the Institute of Cardio-vascular Diseases, has been planning to establish a nuclear medicine unit for investigation of heart patients. The assistance from the RCA is requested im the form of supplying a gamma camera suitable for dynamic studies of heart. Possible source of assistance from JIACA/RCA may be explored.

4. HEALTH RELATED ENVIRONMENTAL RESEARCH

Bangladesh Atomic Energy Commission has been participating in the RCA project on health related environmental research since 1977. The Atomic Energy Centre, Dhaka has developed the relevant methods using PIXE and XRF. In some cases, the non-nuclear method of Atomic Absorption Spectro-photometry(AAS) has been used for the confirmation of analytical data. The achievements to-date may be summarised as follows:-

- Systematic analytical procedures for trace element analysis in biological materials such as hair, blood, nail, serum, urine, plant materials, etc. and environmental samples like soil have been developed, using the method of PIXE.

- Analytical methods (PIXE and XRF) for trace element analysis in liquids including water and motor oil have been developed.

- A method of internal beam PIXE for air-particulate analysis after size fractionation is now under development.

In future we plan to work in the following aspects of health-related environmental problems:

- The study of the relationship between the body burden of heavy elements and the environmental and occupational factors.

- Systematic analysis of aerosols in terms of their size fraction using cascade impractor techniques and PIXE for multi-element characterisation.

- To study the level of nutritional and toxic elements in commonly consumed food items in Bangladesh.

- To study the level of Cd and Se in surface water.

In experimental developments, we are progressing in installing a PDP-11/04 computer system for on-line PIXE and XRF data analysis. Further development should include the proton microbeam generation and the development of PIXE induced XRF method for multielement analysis. The development of Rutherford backscattering method for light element analysis in aerosol is already in progress.

5. NON-DESTRUCTIVE TESTING(NDT)

Bangladesh Atomic Energy Commission has been providing NDT services to different industries and related organizations of the country such as oil refinery, power stations, chemical and pharmaceutical industries, fertilizer factories etc. and to some private firms. At present the services are limited to industrial radiography and ultrasonic thickness gauging. It is planned to develop neutron radiography after the installation of the research reactor at the AERE, Savar.

A 3-week Training Course on NDT practices was conducted from 5 June, 1983 where the relevant industries in the country sent their participants.

6. HYDROLOGY AND SEDIMENTOLOGY

An IAEA expert visited Bangladesh for one month for organizing a programme on the study of sand and silt movement at Chittagong and Chalna harbours by radioactive tracer technique. A programme has been drawn-up for this study and the IAEA has been requested to provide necessary technical assistance under the 1984 programme.

7. RADIATION PROCESSING

Following the UNDP Industrial Project, a research programme on Radiation Vulcanization of Rubber Latex has been taken up at the Institute of Nuclear Science and Technology, AERE, Savar. Some 12,000 seedlings of rubber plants have been planted in an area of 5 acres of land at the AERE, Savar. One scientist of this project went to Indonesia to participate in the natural rubber vulcanization pilot plant under the RCA/UNDP project. The group plans to manufacture gloves, latex thread, foam, rubberised coier, condoms, catheters, baloons, teats, soothers, bathing caps, football bladders, adhesives, carpet backings, castings etc. at a pilot plant scale and make the marketing studies in order to see the feasibility of making these industries in Bangladesh.

Some work on the radiation induced fibre-board plastic composite formation has already been carried out. The effect of dose rate on the amount of polymethyl methacrylate in hardboard and partex has been determined experimentally. At 1 Mrad radiation dose the polymerisation was found to be 80% complete.

8. NUCLEAR INSTRUMENTS MAINTENANCE

A number of laboratories have been selected for pilot laboratory studies under this programme and notable achievements have been made in recording voltage, temperature and relative humidity, and installation of drop out relays in some of the sophisticated medical equipment. Very recently, preventive maintenance planning has been introduced in this project as an introductory parameter, before going into details with the computerized maintenance planning. The National Project Supervisor has already given a seminar on computarized maintenance planning. Mr. Peter Ambro, an IAEA Expert, visited Bangladesh Atomic Energy Commission from January 29 - February 7, 1984. During his stay he helped to implement the BASIC program for the computerized maintenance planning in the Apple II plus microprocessor computer at the Institute of Electronics and Materials Science, AERE, Savar.

The Electronics laboratory of the AEC, Dhaka is regularly conducting training seminars both for the maintenance people and the instrument users and operators. The last 3-week course on

"Nuclear Instrumentation and Maintenance" for the Technicians and operators started on July 24,1983 and attended by 21 participants. The programme of "Train the Trainers" under this project has been found to be fruitful and we suggest that more such courses may be organized by the Agency.

9. <u>DEVELOPMENT OF SEMI-DWARF MUTANTS FOR RICE IMPROVEMENT</u>

Some progress has already been made in the evaluation of semi-dwarf mutants in cross-breeding and providing alternate gene sources for semi-dwarfness with different plant architecture and in different genetic background. In this regard, agronomic evaluation, cytological and genetic studies and cross breeding studies have been peformed in two mutants of IR8 and 4 mutants of a local variety of rice "Nizersail". Some mutants were found to be earlier muturing by 1 to 3 weeks compared to the mother variety. Two of the four mutants showed increased yield over the mother variety. Except one mutant, other three were found to contain higher protein.

10. <u>IMPROVEMENT OF GRAIN LEGUME PRODUCTION</u>

Research on the improvement of mungbean, black gram and chick-pea has been continued at the Institute of Nuclear Agriculture with regard to yield, plant architecture cooking quality, uniform maturity, nitrogen fixation, pest and disease resistance etc. In some cases, the studies have already been continued to the M_3 generation with positive results.

NEW PROPOSALS

I. Re-utilization of Agricultural and Agro-industrial residues through Nuclear Technology.

Cellulosic and liqnocellulosic residues of agricultural and agroindustrial residues are potential renewable resources which can be converted to energy and other essential commodities.

Following the consideration of this proposal to include in RCA programme in last Working Group Meeting in Dhaka, we have started some works in this field. Present work centers around a) development of a good microbial system for enzymatic degradation of cellulosic wastes like bagasse, straw,sawdust, jutestick, newspaper wastes etc. to fermentable sugars. Once fermentable sugars are obtained these could be converted to alcohol or other liquid fuels and other important chemicals by using appropriate microbial systems. b) development of an economic pretreatment method making lignocellulosic substances amenable to enzymatic hydrolysis. Physical, chemical and combination treatments are being assessed.

The project has been submitted to the IAEA for consideration to include under RCA programme.

II. Tissue Bank

At the Institute of Food and Raidation Biology, Bangladesh Atomic Energy Commission we are trying to develop a Tissue Bank with an aim of radiation sterilization and preservation of various human tissues like bones, cartilages, skin, dura mater, tympanic and embryonic membranes etc.needed for human surgery.There has been very encouraging response from the doctors here who deal with tissue grafting.Professor G.O. Phillips, an expert on medical sterilization and Dr.R.N. Mukherjee of IAEA visited our Institute last year. They also met some of the surgeons at Dhaka who will be the actual end-users of such tissues and grafts. In his report, Professor Phillips has strongly advocated for the development of such facilities in our country. In this connection a project has already been submitted to IAEA which is under active considera-tion. It is proposed that this project should be included under RCA programme for the benefit of the regional countries.

SIXTH RCA WORKING GROUP MEETING

COUNTRY STATEMENT - INDIA

India is particularly happy that the 6th RCA Working Group is being held at the Reactor Research Centre at Kalpakkam. The visit of delegations from the RCA member states to this Centre will, it is hoped, lead to an enlargement of the scope and range of India's involvement in coordinated research programmes under the RCA.

India has emphasized the use of RCA programmes as vehicles for manpower training by member states, sharing facilities and expertise available in the region on a multilateral basis. During the meeting participants would see that India has had the benefit of building up the infrastructure in various advanced and sophisticated aspects of nuclear technology as a consequence of embarking on a large power reactor programme and a fast reactor programme. These represent the first and second stages of our long-term strategy in atomic energy. At the Reactor Research Centre and at the Madras Atomic Power Station a broad range of experience and expertise exists in power reactor and fast reactor design, construction and commissioning, in fuel and waste management and in health related radiation safety and environmental control.

India would be willing to examine the possibilities of sharing its experience with member states through RCA programmes.

Since the 5th Working Group held at Dhaka, India has conducted a highly successful 3-week Workshop on the Use of Microprocessors in Research Reactor Utilization at the Bhabha Atomic Research Centre at Bombay from January 30 to Feb. 17, 1984. Ten participants from six member states and a representative of the Agency from the Seibersdorf Laboratory attended the Workshop. The intensive Course was intended for research scientists using radiations from reactors and was also attended by engineers connected with research reactor operation. The Course was aimed at giving them actual experience in designing and constructing systems based on microprocessors and was extremely useful. Many requests for follow up and bilateral and multilateral contacts have resulted from the interaction among participants.

In view of the success of this Workshop at this Working Group meeting India would like to propose a two to three week Workshop devoted wholly to one of the topics dealt with at the previous Workshop, viz. Neutron Activation Analysis. This Course will deal with the finer details of the techniques, using modern equipment and methods, as adapted to real applications in material sciences, forensic science, environmental sciences, geochemical and biomedical investigations. It is our hope that the response of the memberstates to this Course will be as enthusiastic. The expenditure on this Workshop, like the previous Workshops would be met out of the special contributions by India.

India has also continued its involvement in the training course on nuclear electronics. A Course was held at BARC during September 1983 at which ten participants from seven countries were present.

India hopes, in view of the success of these Workshops that the Agency will consider ways of augmenting India's efforts with its own contributions in the form of equipment and travel funds as formulated by the course organisers.

As a consequence of the discussion at the Dhaka meeting and subsequently at the time of the General Conference in Vienna, the Agency has expressed an interest in reviving coordinated research in neutron scattering. India has extended an invitation to the Agency to hold a Consultants' Meeting in this connection in Bombay during December, 1984. In this context, India would like to offer time for experiments with neutron beam facilities under the RCA.

One of the major RCA activities is the Regional Industrial Project on Radioisotope Application, funded jointly by UNDP and the governments of the region. India is playing a leading role in several sub-projects including Tracer Technology, Radiation Sterilisation and Non-Destructive Testing. Training and Demonstration programmes organised under the project are found to be generally useful and will help technology transfer in the region. India welcomes these activities and will continue to support them and play an active role through participation and provision of expertise. However, India would like to advise some caution in the matter of market surveys in the region for nucleonic instruments and radiation equipment as well as to assess the scope for technology transfer. In our view this will not only divert scarce scientific manpower and other resources but could lead to misleading and inaccurate results because such studies are premature at this stage before all projects have reached a demonstration stage.

In the area of medical programmes, India attaches great importance to training activities in cancer treatment such as remote after-loading technique in uterine cancers. At the same time, we support coordinated research programmes in combinational techniques in cancer therapy.

In the area of crop improvement, India will continue to support coordinated research programmes aimed at raising grain legume production and evaluation of mutant stocks. However, it must be recognised that these techniques have a gestation period of about a decade and interest has to be maintained for such a period. India also suggests a coordinated research programme in the area of nitrogen fixation by the grain legume crops.

In conclusion, we wish to reemphasise that India attaches great importance to RCA sponsored coordinated research both in training manpower and in evolving viable, large scale national efforts in areas of economic importance like application of radiation and radioisotopes in medicine, industry and agriculture and in newer areas like nuclear power. Of overriding importance is to sustain public and governmental interest in nuclear science and technology and to highlight the need for a commonality of approach in the region because of the similarity of conditions and problems.

SIXTH RCA WORKING GROUP MEETING

COUNTRY STATEMENT - INDONESIA

Mr. Chairman, Distinguished Delegates, Ladies and Gentlemen.

It is indeed a pleasure for me to be able to be here with you to day, to attend the 6th RCA working group meeting in Madras India. It is also my great honour to be given the opportunity to say a few words in this occation on behalf of the Indonesian Government.

Indonesia as one of the member states of the RCA, is fully aware to the advantages of RCA, mainly in the development of nuclear science and technology, where the goal of this project is transfer of technology to regional industries having important economic and social benefits. Therefore Indonesia will always participate and support all the cooperative research project.

Regarding RCA/UNDP Industrial Isotopes and Radiation Project, it is the honour for the Government of Indonesia that for the sub project of Radiation Processing, Indonesia had been appointed for placement of the rubber latex pilot plant and electron beam pilot plan for surface coating of wood product.
The rubber latex pilot plan with 215.000 Curies of Co^{60} has been in operation since November 1983 and officially opened by the President of Indonesia at 8th December 1983, it coincided with 25th years of anniversary of National Atomic Energy of Indonesia or BATAN.

First Training and Demonstration on Radiation of Vulcanization of Rubber Latex is still underway until the end of March. Six participant from other countries take part in this training, those are from Bangladesh, India, Pakistan, Malaysia, Sri Lanka and Thailand and of course also some staffs from Centre for the Application of Isotopes and Radiation, where this pilot plant is located.

Concerning electron beam pilot plant, the building is still under construction and it will be ready before the equipment come from Japan. Mean while 3 persons have been sent to Japan to study and being trained to utilize this machine.

Radiation processing activities

Activities in the field of radiation processing conducted in Indonesia are classified into 4 groups.

1. Radiation pasteurization and sterilization of medical products and devices.

Products routinely sterilized by irradiation using a minimum absorbed dose of 25 kGy are : pharmaceuticals and its raw materials such as tetracycline HCl ointment in Al-tubes, framycetine in medicated dressing, tetracycline powder, glucose powder and several items of hormon powder, several kinds of dressing, containers, petridishes and eye droppers.

Products routinely pasteurized by irradiation are : talcum powder, amylum, dried herbal medicines and several kinds of cosmetics.

Demand for irradiation services seems to be increasing by the times.

2. Food Irradiation.

The purpose of the study was to extend the storage life, and to improve the hygiene conditions of important food commodities using radiation disinfestation, radurization or radicidation techniques.

Among the food items studied were: rice, wheat flour, dried fish, frozen shrimps and froglegs, whole and ground spices, fresh fruits, and animal feeds. Some of the experiments have been scaled up to evaluate the technological and economic feasibility of the irradiation process. Activities conducted during the last few years were directed to immediate practical application of this technology in the country.
Attemps to get clearance of irradiated food for human consumption from the national health authorities was done by organizing a national seminar on food preservation by irradiation in Jakarta, last year. The seminar was jointly organized by the National Atomic Energy Agency, Directorate General for Food and Drug Control of the Department of Health and the IAEA.

3. Sludge irradiation

The possible use of irradiation to eliminate bacteria in sludge inteded for fertilizer or animal feeds is now under investigation. This study is supported by the IAEA as a research contract.

4. Latex irradiation

The prospect of latex irradiation is very promissing. Although it is still in promotion and marketing studies it is predicted that more than 500 tons/month of irradiation latex will be readily consumed by industries associated with rubber latex material. This figure is optimistically will increase due to the development of some industries.

In the other sub projects of the RCA/UNDP Industrial Isotopes and Radiation Project, Indonesia was participating in the training and demonstration course that have been conducted, like training in NDT, Tracer Technology, Nucleonic Control System and Radiation Sterilization of Medical Product.

Activity in Non Destructive Technique

National Atomic Energy Of Indonesia or B A T A N conducted radiography courses for NDT level I (operator) and NDT level II (radiographer) based upon ASNT standard since 1978. The participant of these courses came from either Government Institution or private NDT companies. Certificate eventually were given to the participants who pass the examination. Up to now there have been 253 persons of NDT level I and 146 persons of NDT level II, however these numbers are still below the demand. To step up capability in NDT inspection, it is considered necessary to conduct the course for NDT level III. It is proposed that IAEA through this project may give assistance by providing experts/lecturer. At present there are about 20 NDT private companies in Indonesia work mainly in radiographic inspection.

Regional Cooperative Project.

Indonesia participate in most of the Regional Cooperative Project under the RCA programme. Nineteen research contracts had been implemented by some Institutes in Indonesia.

Application for new research contract for several topics have been forwarded to IAEA and now just waiting for the approval.

Thank you.

SIXTH RCA WORKING GROUP MEETING

COUNTRY STATEMENT - JAPAN

1. Since its participation in August 1978, the Government of Japan has attached great interest in cooperative activities of the RCA and has contributed greatly in both the technical and financial aspects of those activities. It is, therefore, our great pleasure and pride to often hear words of praise given to the RCA activities by many countries.

2. The Japanese RCA cooperation is based on the policy of technical cooperation with aims at "human resources development" of the member states of the RCA, which we have repeatedly emphasized on many occasions such as the RCA General Conferences and the RCA Working Group Meetings.

3. The Government of Japan shifted financial contribution from the Food Irradiation Project to the new project of Medical and Biological Application. With regard to a cooperation in kind to the second phase of the Food Irradition Project, however, we will stand ready to give our maximum consideration to its possibility when a specific request is made by the IAEA or by participating countries. The Government of Japan will continue to make as much effort as possible to support the RCA/UNDP Industrial Projects and the new Medical and Biological Application Project, especially in the field of Nuclear Medicine and Cancer Therapy.

4.

4. This year, after this meeting, the Government of Japan intends to initiate necessary measures to sponsor in kind or host the following programs with close cooperation and support of various organizations concerned in Japan.

(1) Study Meeting on Nuclear Medicine and Related Subjects sponsored by JICA, August

(2) Second RCA/UNDP Workshop on Nucleonic Control Systems for Steel Industry, this autumn

(3) Third Training Seminar on Nucleonic Instrumentation Engineering, this autumn

(4) Regional Training Course for Medical Technologists in Radiotherapy, October to November

4. In spite of the serious budgetary constraints with call for a 0.1% cut in the Government's general expenditure for the fiscal year 1984, the Government of Japan, in recognition of the importance of the RCA activities, intends to make a financial contribution for this year, subject to approval by the Diet, up to US$381,320, a figure representing a 27.1% increase over last year. In addition certain in kind contributions are considered. The Government of Japan hopes that its financial contribution will be utilized in effective manner and that the IAEA makes further efforts for curtailment of its expenditure.

SIXTH RCA WORKING GROUP MEETING

COUNTRY STATEMENT - REPUBLIC OF KOREA

The Republic of Korea, as a member state of RCA, will participate and support invariably all the cooperative projects, especially the RCA/UNDP Industrial Project. The Republic of Korea believes that the RCA is one important means of accomplishing intra-regional cooperation and technology transfer of the peaceful uses of atomic energy.

Regarding the RCA/UNDP Industrial Project, it is the Republic of Korea's pleasure to support the second training-demonstration workshop on radiation sterilization of medical supplies which is scheduled for two weeks in October this year at the Korea Advanced Energy Research Institute followed by the course at the Bhabha Atomic Research Center of India.

My Government would also like to call your kind attention to the fact that the RCA research coordination meeting on food irradiation as well as the 4th regional project meeting for food irradiation will be held at KAERI during April 9 to 13 of this year.

Concerning the new project on the medical and biological applications of nuclear techniques, we would like to express our welcome for the Agency's approval and hope to play an important role in implementing this regional project. We propose, however, to effect the equal achievement using less funds by utilizing existing multiple centers which are already installed at some of the facilities instead of only utilizing single centers.

In this connection, we hope some of the medical equipment such as a medical cyclotron with 50 MeV and two 22 MeV medical microtrons could be used for the demonstration training purpose of this new project. This medical equipment will be available from October of this year upon completion of a new Cancer Research Hospital of KAERI. The newly constructed Cancer Research Hospital will have 500 beds and will be equipped with latest medical instruments.

We would like to reiterate that the ph ase two food irradiation project be extended additional years so as to gear up the commercialization of this technique in the Region. In the Republic of Korea, a commercial food irradiation plant is planned in the near future, and in this connection technical assistance and cooperation under the umbrella of the RCA is needed.

Regarding the research reactor utilization project which actually began this year with the training course at the BARC, we hope this project being carried out will successfully give more profound knowledge on reactor technology for the member states.

The Government of the Republic of Korea would like to thank the Government of India for hosting this 6th Working Group Meeting of the RCA and we are looking forward to holding the 8th such meeting in Seoul in 1986 as previously agreed during the 12th RCA Representatives Meeting in Vienna in October, 1983.

Thank you.

SIXTH RCA WORKING GROUP MEETING

COUNTRY STATEMENT - MALAYSIA

1. RCA is now coming to the middle of the third consecutive 5 years (1982-1986) period of its regional cooperative programmes. Within this period many research projects have been carried out some of which have been completed while others are still going on. At the same time new programmes emerge such as medical and biological application of nuclear techniques, basic science research using research reactors and energy from agricultural and agroindustrial residues through the use of radiation together with industrial microorganisms. At present, Malaysia is involved in practically all of RCA programmes.

Domestic Buffalo Production Improvement

2. This project was started in October 1979 and terminated in September 1983. Radioimmunoassay techniques for the measurement of plasma concentrations of progesterone and luteinizing hormone were developed in order to study postpartum ovarian function in suckled buffalo. The studies have shown that temporary removal of the calf induced anovulatory oestrus which could be overcome by pretreatment with a progesterone intravaginal coil. However, poor body condition appears to exert an adverse effect on ovarian cyclicity. As a result, further study on the rule of nutrition on post partum reproduction in the buffalo is necessary. This study will be carried out under the phase II programme.

Isotope Applications to Hydrology and Sedimentology

3. This programme started in April 1980 and will continue until 1985/1986. There are several ongoing projects under this programme viz:

i. Environmental isotope investigations in the Kelantan Basin and the Kedah/Perlis area - to study the mechanisms of recharge of groundwater system, origin of recharge and dating of groundwater.

ii. Application of environmental Cs-137 to sediment redistribution in the Lui River Catchment Area and Sediment accumulation in Air Itam Reservoir on Penang Island.

4. Malaysia is very grateful to IAEA and the Government of Australia for their assistance in making this programme a success. It is also hoped that a project review meeting on isotope hydrology and sedimentology will be resumed probably in 1985.

Maintenance of Nuclear Instrument

5. This programme has been carried out since December 1979 and will continue until Oct. 1984. The programme includes environmental recording, development of power-conditioning system, work procedures for maintenance management, development of computer-based maintenance system and training. In future, further work will be carried out;

i. on the planning and implementation of environmental conditioning and the monitoring of the effects of the implemented measures.

ii. to develop and implement further computerized maintenance plans.

iii. to conduct training on nuclear instruments, maintenance and microprocesser techniques.

A Regional Train-the-Trainers Workshop will be held at the Nuclear Energy Unit, Prime Minister's Department, PUSPATI Complexs, Bangi, in October this year.

Food Irradiation

6. A study on the effect of gamma irradiation on volatile compounds in pepper, sensory qualities and the control of pest infestation which started in 1981 was completed in January 1984. The results on transportation study which was conducted between Malaysia and Japan have been

received from Japan recently. The final analysis of the results and the final report will be presented at the RPFI meeting in Seoul, Korea, in April this year.

Health Related to Environmental Research

7. The project on scalp hair as a monitor for community exposure to the environment was conducted on two population groups living in different regions of Malaysia. The concentratins of Co, Fe, As, Cr and Hg were shown to be different between rural and urban areas. The project which was started in November 1980 will be terminated in March 1984.

8. A new project on the analysis of trace elements in food staff such as rice, fish, meat and vegetables will be carried out as part of the Food Contamination Analysis Programme organised by the Health Authority of Malaysia.

Improvement of Grain Legume Production

9. Two projects being carried out under this programme in Malaysia namely Soybean Mutation Breeding and Rice Mutation Breeding. Soybean Mutation Breeding is part of the Joint Malaysia Soybean Breeding Project involving 5 Institutions in Malaysia. The Regional Coordinated Programme on Mutation Breeding was to have been terminated by the end of 1983. However Malaysia strongly hopes that this programme to be continued. The soybean project is still an on going project and the yield trials of the advanced-generation (M5) mutant in actual farming situation is yet to be tested.

Medical and Biological Application of Nuclear Techniques

10. A project on the evaluation of interferon-radiotherapy combination in the treatment of Nasopharyngeal Carcinoma is being carried out since March 1983 by the Institute of Radiotherapy, Oncology and Nuclear Medicine, General Hospital, Kuala Lumpur.

11. Malaysia is honored to have been chosen to host a Regional Training Workshop on Brachytherapy of the Uterus Cancer using Manual and Remote After Loading Techniques which will be scheduled to be held in November/December 1984. The workshop will be jointly organised by the National University of Malaysia (UKM) and the Institute of Radiotherapy, General Hospital.

12. The Medical Faculty of the National University of Malaysia has submitted a project proposal on the use of Radioactive Iodine (I-131 and I-125) in the diagnosis and treatment of Thyroid, Liver and Adrenal diseases. It is very much hoped that the programme will be implemented as planned.

13. At present, a project on the Diagnosis of Plasmodium Falciparum infection using solid-phase radioimmunoassay is carried out by the Medical Faculty of the University of Malaya. This project has been going on for almost 2 years starting in July 1982 under IAEA research contract. It is hope that this project will be included as part of the above regional coordinated programme.

14. The work on the development of ^{99}Mo-^{99m}Tc column type generator based on zirconium molybdate GEL using TRIGA MARK II research reactor will be carried out at the Nuclear Energy Unit (UTN) in April 1984.

RCA/UNDP Industrial Project

15. Malaysia has been actively participating in the training programme on industrial projects. Several personnel from the paper, steel and mineral industries have been attending the training - demonstration in nucleonic control system. The training courses for our NDT personnel are considered to be invaluable. Malaysia is in the process of developing a NDT certification scheme.

16. The maintenance of nuclear instrument is going to play an important part in the development of nuclear technology in this country. Industrial project on nucleonic instrument maintenance is part of the maintenance of nuclear instruments programme from which the experience

gained will help to increase the efficiency, reliability and quality of work in all aspects of maintenance.

17. Malaysia is also actively participating in the industrial project on radiation processing. Two series of accelerated test-evaluation programmes for radiation vulcanization of natural rubber latex were undertaken in 1983 in collaboration with TRCRE (Japan), CAIR (Indonesia) and RRI (Sri Lanka).

IAEA REGIONAL CO-OPERATIVE AGREEMENT

6th WORKING GROUP MEETING

MARCH 20 - 23, 1984

COUNTRY STATEMENT FROM THAILAND

Mr. Chairman, Prof. Zifferero, Dr. Kobayashi, distinguish delegates, and local participating members.

Government of Thailand has been participating in RCA since its early stage of formulation and its implementation stage. The Atomic Energy Commission (AEC) of Thailand, through the Office of Atomic Energy for Peace (OAEP) as its functioning arm, has made constant effort to co-operate, to participate, and to contribute to all the RCA activities.

The current research and development in nuclear science and technology related to RCA activities are Commercialization of Food Irradiation, Nuclear Techniques to Improve Domestic Buffalo Production, Utilization of Research Reactor, and Industrial Application of Radioisotopes. Government of Thailand also supports all the Co-ordinated Research Project putforth by the Agency.

Commercialization of Food Irradiation

Various government agencies and private firms has shown interests in setting up a commercial plant for food irradiation service. The present concentration is on irradiation of frozen seafood, onions and potatoes. Upon request, the Agency has agreed to assist by sending expert to review the feasibility study. It is expected that certain decision will be made by the end of this year (1984).

Nuclear Technique to Improve Domestic Buffalo Production

The Co-ordinated Research Project under RCA has proved to be useful to buffalo production in Thailand. As a result, the Government of Thailand are convinced of the usefulness of nuclear technique and puts it under the fifth five-year national development plan (1982-1986).

Utilization of Research Reactor

OAEP has long been interested in effective utilization of research reactor since its first research reactor was commissioned in 1962. Currently, the present research reactor, TRIGA MARK III, is being upgraded to accommodate the expanded isotope production capacities. However, the utilization of research reactor in other research and development areas are also being carried on.

Industrial Application of Radioisotopes

Currently, the activities under the UNDP Regional Industrial Project have given awareness of usefulness of radioisotopes applications among industrialists. Two nucleonic control systems have been installed in paper mills since the first training demonstration workshop in 1982. Three more systems are being finalized for smaller capacity paper mills.

A Thai Society of Non-Destructive Testing (TSNDT) has been recently set up to act as national body for training and certification in NDT.

A commercial plant on sterilization of medical supplies has been commissioned on March 13, 1984. The management of the plant has also shown interest in the sterilization of Biological Tissue Grafts.

The above mentioned activities have illustrated the progress and the impacts of the RCA activities in Thailand. With beeter planned objectives, and more support from the Agency, the RCA will prove to be one of the most beneficial programmes to its member states.