INTERNATIONAL ATOMIC ENERGY AGENCY

IAEA-PDE-93/01
26 March 1993
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PROJECT DESK EVALUATION

A DESK EVALUATION REVIEW OF PROJECT

BGD/5/010

FOOD IRRADIATION

DEPARTMENT OF TECHNICAL CO-OPERATION

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EVALUATION SECTION

DEPARTMENT OF TECHNICAL CO-OPERATION

PROJECT DESK EVALUATIONS

Project Desk Evaluation (PDE) is an intensive review process, using agreed guidelines, of the design, implementation, and the outputs of a project. Its purpose is to convey concisely as comprehensive a picture of a project's performance as can be obtained without a specific evaluation mission to the project site. It also seeks, where possible, to draw generalizable lessons that go beyond the specific project under review. Frequently, Project Desk Evaluations are conducted on a set of similar projects, e.g. radiation protection projects or projects in nuclear medicine, in various countries and reported on together. In this way a wide range of approaches, strategies, problems and trends relating to a common type of undertaking can be examined and conclusions confidentially drawn.

Project Desk Evaluations are carried out by the staff of the Evaluation Section, Department of Technical Co-operation, with the assistance of the relevant staff in the Agency concerned with the specific projects. Upon completion, each Project Desk Evaluation is submitted to the Deputy Director General of the Department of Technical Co-operation.

DESK EVALUATION REVIEW OF PROJECT

BGD/5/010
FOOD IRRADIATION

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EXECUTIVE SUMMARY

Shortage of food is a chronic problem in Bangladesh. Although food production has been rising steadily, the increased output can barely keep pace with population growth. Because of the dense population, further increases in agricultural production using existing methods are limited by the availability of land for cultivation. Moreover, huge post-harvest losses of both agricultural and fishery products occur due to insect infestation, rotting and sprouting. To increase the availability of food, the Bangladesh Atomic Energy Commission (BAEC), through its Institute of Food and Radiation Biology (IFRB), has for many years pursued research studies in the use of ionizing radiation for food disinfestation and preservation. The Agency has been assisting these research efforts since the late 1970s.

Project BGD/5/010, Food Irradiation, as reformulated in 1984, was to take on-going activities one step further, with the main objective of demonstrating on a semi-commercial scale the efficacy and profitability of food irradiation in reducing the high storage losses of economically important food, such as potatoes, onions, dried fish and other seafood. A further objective was the transfer of food irradiation technology to the relevant industries in Bangladesh.

The total budget of the project for the years 1983 through 1992 includes 5.1 man-months of expert services, $1 064 634 for equipment and $29 200 for training.

The review was undertaken upon request by the Asia and the Pacific Section, to assess the current status of this ten-year project, which has encountered numerous delays and set-backs and is now nearing completion, and to determine to what extent the experience gained on the project could be useful in the implementation of similar on-going and future projects.

ACCOMPLISHMENTS

As of 1 March 1993, the project has provided a total of 5.5 man-months of expert services, equipment valued at $1 029 102, as well as two fellowships and one scientific visit for a total of 22.5 months of training abroad. In addition, some 80 man-months of training was provided through project-related fellowships and scientific visits and through participation in regional group training events.

A key achievement early in the project was the conclusion of an agreement between BAEC and a major commercial organization (BEXIMCO), which has provided land at Chittagong, financed the construction of the building, and contributed to local costs up to an agreed maximum. Under this agreement, a joint venture company (Gammatech Ltd.) was formed to establish, operate and manage irradiation plants in Bangladesh. The significance of this arrangement is the involvement of the food industry, necessary to exploit the technology to the benefit of the country.

General public acceptance of irradiated foods, essential for these plans to succeed, has already been achieved through test marketing of various items of food and through a public information programme and seminars held for interested industrialists and the press. There is a keen interest in the process among entrepreneurs. Through BAEC, the programme enjoys strong support by the Government, including the funding of staff, facilities and equipment, and conclusion of the agreement with BEXIMCO. Legal clearance has been obtained for irradiation as a process for treatment of food and agricultural products, and a large number of food items have already been approved for treatment by irradiation.

Excellent progress has been made on technical aspects, including identification of appropriate products, product mix, volumes, densities and required dosages, and development of suitable packaging materials, methods and storage standards. Assisted by the expert advice, training and equipment provided by the Agency under its technical co-operation programme -- as well as by contracts awarded under the Agency's research contract programme -- IFRB has achieved a high level of expertise in food irradiation technology; according to the Technical Officer, among the highest in the world. Between 1987 and 1990, ten scientific papers and publications on food irradiation, prepared by the Institute, appeared in journals and national and international conference proceedings.

Through the acquisition of a USSR irradiator, the Agency has succeeded in making use of a substantial amount of non-convertible currency. However, a serious drawback, particularly in the early stages of the project, was that communications with the USSR supplier were not always satisfactory and that the visits to the project site by the USSR specialists were frequently delayed, partly owing to visa problems. Thus a number of scheduled meetings with Agency staff/expert missions to the project could not take place, to the detriment of smooth and timely implementation of the project. Key decisions were taken without Agency participation and repeated revisions of the implementation schedule were required.

In April 1991, disaster struck with a cyclone and tidal bore which heavily damaged some still not quite finished buildings and soaked the stored crates of equipment with salt and rain water. More than 18 months were required to effect the repairs on the damaged building and equipment. Installation of the equipment and source could finally be started in November 1992 and has now been completed. The plant will be officially inaugurated on 30 March 1993.

Economic feasibility studies are at present being undertaken for a second facility, planned by BEXIMCO for Dhaka. Other, commercially-funded plants may follow, based on the experience gained at the Chittagong demonstration facility.

FINDINGS

As already stated in the 1987 evaluation of the project, the general goal is to increase the availability of food to the population of the country, to reduce dependence upon imported food, and to increase earnings from food exports. In pursuit of this general goal, the main objective of the project is to establish a semi-commercial irradiation facility to demonstrate the efficacy and profitability of food irradiation in reducing the high storage losses of food, particularly of economically important items, such as potatoes, onions, and dried fish. Successful demonstration of irradiation technology in food disinfestation and preservation on a semi-commercial scale was expected to lead to the establishment of a network of commercially-financed irradiation facilities.

The objectives of project BGD/5/010 have been only partially achieved. An effective transfer of technology has taken place, and a highly qualified cadre of scientific and tech-

nical staff has been built up at IFRB and Gammatech, able to put into practice the technology acquired, once the facility has been commissioned.

Excellent work has been done on the public information sector, stimulating the interest of private enterprise in the technique and showing promise for commercial funding of additional plants, once the Chittagong facility has demonstrated the economic advantages of the process on a semi-commercial scale. With general public acceptance already achieved through test marketing, and with the existing strong Government support, no problems are expected for marketing the irradiated food items once the plant will be in operation.

Economic profit for the plant is expected in the treatment of dried fish, potatoes, onions and pulses. In particular, the facility will be able to produce about 6500 t of irradiated, non-toxic dried fish per annum, in replacement of dried fish formerly treated with pesticides and showing high toxic levels.

Installation of the irradiation facility, initially planned for 1987 and subsequently confirmed by the suppliers for 1988, has been delayed by five years, mainly because the building to house the equipment could only be completed in late 1992. A number of factors have contributed to this construction delay in the earlier stages of the project, e.g. unsatisfactory communication links with the USSR suppliers of equipment, who rarely replied promptly to a request by the Agency or BAEC, or both; the repeated failure of their representatives to reach the project site in time for meeting with Agency staff or experts, to discuss and decide upon important issues; delayed and unclear specifications as well as contradictory construction designs. In addition, shipments of equipment arrived late and/or not accompanied by negotiable shipping documents, resulting in further delays before the equipment could be cleared through customs.

Failing to reach Bangladesh in time for Loaharanu's visit in December 1985, the USSR specialists did arrive in January 1986; failing to meet Stenger in June 1987, they did visit the project in August/September 1987. In both cases, the earlier Agency visits had been for the purpose of meeting with the supplier representatives to discuss and decide upon important issues, and in both cases the Agency decided not to send a second mission. Agency guidance during these two delayed visits by the USSR specialists might have contributed to avoiding some of the subsequent delays.

The recurrent difficulties and delays through not requesting and obtaining visas for the installation specialists in a timely fashion, a problem not unique to the project on hand, may have been avoided if an attempt had been made early in the project to obtain visas for multiple entries.

It is, at this point, idle to speculate what the effects of the cyclone/tidal bore disaster in April 1991 would have been, had the project been implemented according to schedule. Certainly, the damage would not have been as heavy if at least the construction of the buildings had been completed by early 1991. Thus, the repeated smaller delays caused by the supplier have contributed to the ultimate, major delay caused by the natural catastrophe.

The advantage of the project utilizing a significant amount of non-convertible currency has been almost entirely offset by the difficulties encountered with the suppliers of the NCC equipment. It would not be appropriate for the Agency to consider any future co-operation with these suppliers, unless ensured of a major improvement and a more competitive approach in their business policy and practices.

On the other hand, Gammatech seems to have been not too effective during the actual construction stage, and progress was slow. More pressure applied by BAEC and BEXIMCO to speed up the construction work might also have minimized the effects of the April 1991 disaster.

In view of the long delay and of the excessive damage done to both building and equipment, it would be prudent to send an expert -- after commissioning of the facility and before closing the project -- to go over the entire facility to determine possible shortcomings within the period of warranty, and to check whether all equipment intended for the Chittagong plant is in place and in good working order.

With the inauguration of the plant on 30 March 1993, the ingredients for a major, if considerably delayed, success are still present. Following its commissioning, the first months of operation of the facility on a semi-commercial scale will be crucial to the future of food irradiation in Bangladesh. At this stage, Gammatech still has to prove its effectiveness under semi-commercial operating conditions.

Continued Agency support of the programme through a small follow-up project may be required for additional training; for refurbishing of the source; for occasional expert advice; and to ensure periodic progress reports, furnishing the Agency with details on the experience gained, which could subsequently be used to advantage in other, similar projects.

RECOMMENDATIONS

(1) After considerable delays in its implementation, project BGD/5/010 is nearing completion. Following inauguration of the irradiation facility on 30 March 1993, and before closure of the project, it is recommended that the funds remaining under the project be used to provide the additional equipment and training requested by the counterpart, and to field a final expert mission to go over the entire facility to determine possible shortcomings within the period of warranty, and to check whether all equipment intended for the Chittagong plant is in place and in good working order.

(2) To ensure the viability of the programme and its impact on the country's economy, it is essential that the Agency continue to monitor the activities of the programme, and of the demonstration facility set up under the project, over the next few years. To this end, it is recommended that the Government request, and the Agency approve, a small follow-up project in support of the plant's activities under semi-commercial operating conditions.

(3) Gammatech Ltd. have not been too effective during the construction of the building to house the irradiation facility and still have to prove their efficiency and effectiveness under semi-commercial operating conditions. It is recommended that BAEC and BEXIMCO closely observe and supervise Gammatech's activities over the next few years.

(4) In view of the difficulties encountered with the suppliers of the irradiation facility, it is recommended that the Agency consider further co-operation with them only if a major improvement and a more competitive approach in their business policy and practices could be ensured.

(5) To avoid delays through recurrent visa problems on future multi-year projects, providing large items of equipment and requiring repeated visits to the project by the suppliers' staff, it is recommended that the Agency, at the time the contract is concluded between supplier and recipient, request both parties to explore the possibilities for obtaining visas for multiple entries into the recipient country.

I

INTRODUCTION

Shortage of food is a chronic problem in Bangladesh. Although food production has been rising steadily, the increased output can barely keep pace with population growth. Because of the dense population, further increases in agricultural production using existing methods are limited by the availability of land for cultivation. Moreover, food preservation methods, such as canning, deep freezing and refrigeration, are almost non-existent for the domestic market, and huge post-harvest losses of both agricultural and fishery products occur due to insect infestation, rotting and sprouting. To increase the availability of food, the Bangladesh Atomic Energy Commission (BAEC), through a special institute, has for many years pursued research studies in the use of ionizing radiation for food disinfestation and preservation. An experimental irradiator was established in the late 1970s, and a semi-commercial irradiation facility is now being provided by the Agency.

The Institute of Food and Radiation Biology (IFRB) of the Atomic Energy Research Establishment (AERE) is a specialized research institute of BAEC. It is authorized to pursue studies in the application of ionizing radiation for the following purposes:

(a) Disinfestation of stored grains, such as rice, wheat and pulses;
(b) Preservation of fresh fish, poultry and red meats;
(c) Shelf life extension of fruits and vegetables;
(d) Sprout inhibition of potatoes, onions, ginger, etc.;
(e) Disinfestation of products, such as dried fish, hides and skins, tobacco and jute;
(f) Mutagenic and toxicity studies of irradiated foods;
(g) Sterilization of medical products and supplies;
(h) Control and management of pests in the field;
(i) Molecular mechanism of gene action and genetic improvement of industrial micro-organisms.

Until 1980, the Institute was known as the Irradiation and Pest Control Research Institute (IPCORI). Agency co-operation with IFRB/IPCORI in the area of food irradiation goes back to 1966, with the award of a research contract on radiation preservation of tropical fruits. Since that time, support under the Research Contract Programme has covered studies on irradiation of grains, fish, seafood, potatoes, onions, pulses, oil seeds, tobacco and medical products.

Assistance under the Technical Co-operation Programme was initiated in 1977 and has been continuous since then. Earlier projects provided expert services on the economic and technological feasibility of food irradiation, and small-scale market testing and consumer acceptance studies; some $63 000 worth of equipment; and training totalling almost 70 man-months. During its long association with the process, the IFRB has developed a high level of expertise in the field of irradiation of food and other products. The Institute has been strongly supported by the Government which in the late 1970s provided a substantial investment, including the purchase of a Gammabeam 650 experimental irradiator.

Project BGD/5/010 was originally approved under the 1983 Regular Programme as a small footnote-a/ project, to provide the services of an expert to advise on packaging methods for stored products, as well as some equipment and training for the local staff. It was reformulated as a multi-year project in 1984, to accommodate a proposal for the supply of a multi-purpose irradiation facility planned to be installed in 1987. It has since been modified a number of times to incorporate subsequent requests for assistance in the area of food irradiation, and to provide additional requirements not foreseen in the original formulation.

A Desk Evaluation Review of the project carried out in late 1987 expressed some caution with regard to the project schedule but, in general, concluded that the ingredients for a major success were present. The current review is being undertaken as the project is nearing completion, with a view to assessing the extent to which the project has achieved its immediate objectives, and is under way of achieving its longer-term objectives, and to determining what lessons can be learned from the developments under the project since the last review.

II

PROJECT UNDER REVIEW

The following section contains a Project Desk Evaluation (PDE) of the Agency's large-scale project BGD/5/010, Food Irradiation.

The review was undertaken upon request by the Asia and the Pacific Section, to assess the current status of this ten-year project, which has encountered numerous delays and set-backs and is now nearing completion, and to determine to what extent the experience gained on the project could be useful in the implementation of similar on-going or future projects. It must be borne in mind, however, that a desk evaluation review is but one element of a critical examination to which there must be a tentative approach and continual testing of its conclusions. As the Joint Inspection Unit concluded:

> "One of the most difficult problems which internal evaluation systems face is the tendency to regard them as a self-contained management technique which merely needs to be introduced into an organization to swiftly improve operation. In fact, evaluation is only a phase -- albeit an important one -- in the basic management cycle. It cannot have its full impact until it becomes part of an overall management system." (Second Report on Evaluation in the United Nations System, para.28, Joint Inspection Unit, JIU. rep.6).

Findings and recommendations are in Sections III and IV of this report.

Project:	BGD/5/010 FOOD IRRADIATION	FINANCIAL SUMMARY
Recipient Institution:	BAEC, Atomic Energy Research Establishment, Institute of Food and Radiation Biology, Dhaka, Bangladesh	
Counterpart:	Mohammad Abdul Dayen BHUIYA	

CURRENT BUDGET ($)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Total
Experts:												
US Funds	15 600	-	-	-	-	-	-	-	-	-	-	15 600
Regular CC	-	6 600	-	-	7 050	-	8 100	-	-	-	-	21 750
Equipment:												
US Funds	25 000	-	4 347	-	-	-	-	-	-	-	-	29 347
Regular CC	-	-	16 000	15 000	30 000	36 000	-	-	20 794	38 000	-	155 794
Regular NCC	-	20 000	260 000	250 000	250 000	99 056	-	437	-	-	-	879 493
Fellowships:												
Regular CC	-	-	18 000	3 000	-	-	8 200	-	-	-	-	29 200

DISBURSEMENTS ($)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Total
Experts:												
US Funds	-	3 321	2 034	1 550	-	-	-	-	7 363	3 913	-	18 181
Regular CC	-	3 645	-	1 454	8 913	-	1 974	2 087	9 637	(2 047)	-	25 663
Equipment:												
US Funds	-	385	1 160	6 384	21 417	-	-	-	-	-	-	29 346
Regular CC	-	-	4 405	11 165	7 474	10 385	-	-	41 093	19 924	27 488	121 934
Regular NCC	-	-	235 227	277 778	6 041	20 251	62 946	241 965	33 039	575	-	877 822
Fellowships:												
Regular CC	-	-	8 949	12 130	118	-	-	7 285	-	-	-	28 482

Current Financial Status (1 March 1993):	US Funds	Regular CC	Regular NCC	Total
Total disbursements ($)	47 527	176 079	877 822	1 101 428
Unliquidated obligations ($) - equipment	-	11 752	188	11 940
Earmarkings ($) - equipment	-	22 109	1 482	23 591
- fellowships	-	717	-	717

APPROVED PROJECT OBJECTIVES AND ACTIVITIES

As originally approved in 1983, the project had the very modest objective of developing packaging methods for stored products, both irradiated and untreated, and devising packaging and storage techniques for irradiated dried fish.

In 1984, the project was reformulated as a multi-year project with the main objective of demonstrating on a semi-commercial scale the efficacy and profitability of food irradiation in reducing the high storage losses of economically important food items, such as potatoes, onions, dried fish and other seafood. A further objective was the transfer of food irradiation technology to the relevant industries in Bangladesh.

The successful achievement of these objectives was expected to advance the Government's plans to establish a total of seven irradiation facilities during its third five-year plan, 1985-1990, five in the private sector and two in the public sector.

The Agency is assisting the Government in these efforts by providing a gamma irradiation facility and accessories, the services of experts, and training for the local staff. The Government has undertaken to construct the building to house the (Agency provided) irradiator, as well as to provide supporting facilities during construction.

Intended target groups and beneficiaries of the project are the national economy and, consequently, the entire population of the country.

PROJECT SUMMARY

Activities prior to BGD/5/010

Assistance under the Agency's Technical Co-operation Programme was initiated in 1977 (BGD/5/004, Food Irradiation). Under this project, expert advice on the economic and technological feasibility of commercial-scale food irradiation was provided, as well as several items of equipment, including a cooled incubator, a moisture extraction oven and a gas-liquid chromatograph. Expert assignments in both areas had been planned for 1978, but due to delays in the installation of the pilot irradiation facility (a 50 000 curie AECL Gammabeam 650), work on technological feasibility had to be deferred until February 1980.

Continued assistance was approved under the 1978 Regular Programme (BGD/5/007, Food Preservation) to provide expert services to guide local scientists on large-scale market testing and consumer acceptance studies of irradiated food. In addition to the Gammabeam 650 pilot facility, BAEC had announced its intention to acquire a larger semi-commercial plant (200 000 to 400 000 curies) for installation early in 1979. Implementation of expert services under BGD/5/007 was planned for late 1979 or early 1980, depending upon the recommendations of experts assigned to BGD/5/004.

Following the delay in implementation of BGD/5/004, assignments under BGD/5/007 were scheduled for early 1981, then rescheduled for early 1982 to accommodate expert availability. In the meantime, the manufacturer of the Gammabeam 650 discovered a fault which required the facility to be shut down for repair in December 1981. Assignments were then rescheduled for early 1983. By that time, however, one of the two experts (Kawashima) was no longer available. The other (Kalman) was asked to cover both task and carried out a three-month assignment in February/April 1983.

The Technical Officer was not satisfied with the expert's report and a follow-up mission by a third expert (Kiss) in March 1986 was decided upon. By that time, BGD/5/010 was well under way and a review of the market testing programme was clearly advisable and timely.

Further assistance was provided under a 1980 footnote-g/ project funded by the USA (BGD/5/008, Food Preservation). In support of the dried fish preservation project at the Institute of Food and Radiation Biology (IFRB), two walk-in chambers were supplied.

Activities under BGD/5/010

Beginning with 1983, all subsequent approvals for assistance to Bangladesh in food irradiation were accumulated under BGD/5/010. The major component of the project is the establishment of a semi-commercial irradiator for which the Agency is providing the equipment plus installation and expert advice on design, construction and operation of the facility. Other elements include expert services and equipment for packaging studies; expert advice on economic feasibility assessment, and a sizable training programme in food irradiation for IFRB staff.

In February 1982, the Bangladesh Atomic Energy Commission (BAEC) submitted two requests for projects in food irradiation for inclusion in the Agency's 1983 Regular Programme, to be carried out at IFRB. Assistance was requested in conducting pilot-scale studies on preservation of potatoes and onions, and in storage, packaging and toxicology of irradiated dried fish.

The Agency was asked to provide expert services of three months in histopathology and toxicology, together with some equipment at an estimated cost of $42 000. Five 12-month fellowships were also requested -- two in toxicology of irradiated food, and one each in potato irradiation, microbiological studies of irradiated dried fish, and packaging of irradiated dried fish. In addition, four 3-month scientific visits were requested, in irradiation of potatoes, onions and fish, and toxicology of irradiated food.

Local staff for implementing the project included Dr. Mainuddin Ahmed, Chief Scientific Officer and Head of IFRB, and six scientists highly experienced in food science, technology and related fields. Facilities included a 50 000 curie gamma irradiator and several large items of laboratory equipment, some of which had been provided through earlier Agency projects. Additional facilities planned included an accelerator, a commercial-scale irradiator, an animal house and expanded laboratory space.

The Technical Officer (Loaharanu) supported a project combining the two requests, with the exception of the toxicology element for which he considered that sufficient data was already available. Rather than three months on toxicology testing which had been requested, he recommended two months of expert services on development of suitable packaging for long-term storage of irradiated food items. With regard to equipment, he supported the items requested, with the exception of a pickup van and an animal stand. He also recommended approval of one fellowship and one scientific visit in food storage and packaging. Approval under the 1983 Regular Programme provided for two months of expert services and $25 000 for equipment under a footnote-g/ project (selected by the USA for extrabudgetary funding in November 1983).

In November 1982, BAEC submitted a supplementary proposal for the supply of a multi-purpose irradiator to be used for sterilization of medical instruments as well as for irradiation of food. The Agency was asked to provide a 200 000 curie Co-60 or Cs-137 pilot-scale plant at an estimated cost off $500 000, plus expert services of one month for installation of the unit, and to train the local staff in its operation and maintenance. In addition, some six-month fellowships and one scientific visit were requested for training in maintenance and repair of the irradiation facility.

Facilities available included dosimetric, electronic and workshop facilities for the installation of the source. BAEC undertook to provide a suitable building to house the facility, and other premises. It was expected that the project would demonstrate, on a semi-commercial scale, the value of irradiation for reducing storage losses of economically important foods, such as potatoes, onions and dried fish.

The Technical Officer (Loaharanu), together with Dr. P. Thomas (Biochemistry and Food Technology Division, BARC, Bombay, India) undertook a mission to Bangladesh in December 1982, to:

- Evaluate the infrastructure required to develop a national programme on food irradiation in Bangladesh;
- Evaluate the techno-economic feasibility of establishing a multi-purpose demonstration irradiator for treating food and medical products;
- Recommend future work to be carried out on food irradiation in the country.

The Technical Officer concluded that the project was highly feasible and enjoyed high Government priority. He recommended acquisition of a 200 000 curie Co-60 batch type or semi-automatic pilot-scale irradiation facility, to be located conveniently close to food and medical products industries. He also recommended expert services of one month in dosimetry with emphasis on process control for large-scale irradiation of food and medical products, and a scientific visit of one month to pilot or industrial irradiators in Europe. Concerning future work on food irradiation in the country, he made the following observations:

1. National regulations on food irradiation should be established. For this purpose, a national steering committee should be formed with representatives of government institutions and local food industries. The Recommended International General Standard for Irradiated Food, and the Recommended Code of Practice for the Operation of Radiation Facilities Used for Treatment of Food (published by the Codex Alimentarius Commission) should be used as guidelines in establishing such national regulations.

2. Pilot-scale technological and economic feasibility studies and market testings should be carried out in the following year in close co-operation with the food industry -- in potatoes, onions and dried fish -- assisted by Agency-provided expert services.

3. There is an urgent need to develop reliable process control for food irradiation and medical products sterilization. An expert in dosimetry with experience in both fields is needed for one or two months under the 1984 Regular Programme.

Approval of a multi-year project under the 1984 Regular Programme provided for short-term expert services, and an irradiator to be installed in Dhaka. Delivery was expected in 1987. In order to utilize non-convertible currency (NCC), the Agency proposed and BAEC accepted, that the irradiator be acquired from a supplier in the USSR. Total approved Agency inputs for the period 1984-87 included four months of expert services and equipment with a convertible currency component of $90 000 and a NCC component of $780 000. Government inputs would include a building to house the facility, and other necessary premises.

Under a request submitted in January 1983 (BGD/84/04), the Agency was asked to assist IFRB's programmes on disinfestation of dried spices and decontamination of animal feeds by gamma irradiation, by providing expert services (5 months), equipment ($18 000), and training (three 12-month fellowships and scientific visits totalling seven months).

The Technical Officer supported the request, reformulated under the title "Radiation Preservation of Dried Food", providing for expert services of two months, equipment at an estimated cost of $22 000, a 12-month fellowship on radiation decontamination of spices, and a one-month scientific visit to commercial food irradiation facilities in Europe. Unused USA funds were available under the project for the expert/equipment component.

In February 1984, another request (BGD/85/11) was made for assistance in radiation of fish and fishery products for elimination of salmonella and extended commercial storage. The Agency was asked to provide expert services of two months, equipment at an estimated cost of $16 000, two 12-month fellowships and two one-month scientific visits.

The request was supported by the Technical Officer and approved under the 1985 Regular Programme, with a provision of $21 000 for laboratory equipment for process development related to the irradiation preservation of seafood, radiation dose optimization and bacteriological/chemical studies on irradiated products. With regard to the expert services required for an evaluation of the commercial feasibility of irradiation preservation of seafood, the inputs already approved were considered to be sufficient to handle this aspect, and no additional provision was made. Training in process control, microbiology and quality assurance of foodstuffs (18 months) was also foreseen.

Still another request in food irradiation (BGD/87/02) was made for approval under the 1987 Regular Programme, for insect disinfestation and preservation of food and agricultural products by radiation, including expert services for three months, equipment at an estimated cost of $20 000, two 12-month fellowships and two three-month scientific visits.

The Technical Officer supported the requested expert services and equipment in total, and also recommended approval of a 12-month fellowship in radiation disinfestation of stored products. Approval under the 1987 Regular Programme provided for three months of expert services (one in 1987 and two in 1988), and $30 000 for equipment.

Under the 1988 Regular Programme, a provision was made of two months of expert services, as well as $100 000 in NCC and $50 000 in CC, for the installation of the facility and to cover the cost of additional plant requirements to be purchased in the USSR, including loading, ventilation, monitoring and communications equipment, and dosimetry instruments. Additional $30 000 was approved under the 1990 Reserve Fund.

Between November 1986 and April 1992, a total of 21 programme changes were made and three re-phasing exercises took place to respond to developments on the project. The total current budget, for the years 1983 through 1992, amounts to $1 131 184 and includes $37 350 (5.1 man-months) for expert services, $1 064 634 for equipment, and $29 200 for fellowships and scientific visits. The provision for equipment thus constitutes 94% of the total budget. Of the total funds available, 96% were provided by the TACF (78% in NCC and 18% in CC), while 4% were made available through an extrabudgetary contribution by the USA.

As of 1 March 1993, total disbursements under the project amount to $1 101 428, total unliquidated obligations to $11 940, and total funds earmarked to $24 308 (see FINANCIAL SUMMARY, page 4). The project has provided a total of 5.5 months of expert services, $1 029 102 worth of equipment, as well as two fellowships and one scientific visit for a total of 22.5 months of training abroad.

IMPLEMENTATION

Equipment and Experts

Since equipment constitutes the major part of the project (over 93%), and since the progress on implementation of this project component significantly influenced the timing of the expert assignments, both components are dealt with together. A list of the equipment provided is given at the end of this section (page 39).

In response to the request by the Asia and the Pacific Section for a cost estimate on the supply of the irradiator, the Head of the Field Procurement Section (Adler) noted that the facility could be supplied by a convertible-currency country at a cost of about $900 000, including the 200 000 curie source, shipment and installation. Alternatively, it could be acquired at almost the same price from the USSR against NCC, except for some mission costs to be paid in convertible currency. Proposed delivery time would be 1987. In order to utilize NCC, the decision was made to supply the USSR irradiator. Two missions, charged to the project's expert component (Task 90), were undertaken by Agency staff members to Bangladesh and the USSR, respectively, to discuss further details:

- P. ADLER & P. LOAHARANU (IAEA) Mar 84 15 days
  - To assist the Bangladesh authorities in the preparation of technical specifications for the food irradiation facility to be provided by the Agency;
  - To review a draft contract between the IAEA and the proposed supplier, Techsnabexport (TENEX), Moscow, USSR; and
  - To advise on selection of a site for the facility.

Discussions with officials of BAEC and IFRB clarified the main specifications of the proposed irradiator, and the terms and conditions under which the facility was to be provided by the selected supplier. BAEC also agreed to provide all necessary buildings to house the irradiator, including radiation shielding. The draft contract was evaluated and modified to meet the requirements of the user, and it was agreed that the contract would be signed during the second half of 1984, calling for installation and commissioning before the end of 1987. For this purpose, representatives of the supplier would be expected to visit Bangladesh before the end of 1984, to inspect the installation site and to discuss technical details with the local authorities.

- P. ADLER & V. MARKOVIC (IAEA) May 84 6 days
  - To visit the Techsnabexport in Moscow to discuss and agree on basic specifications for the irradiator to be supplied to Bangladesh.

Agreement was obtained on most of BAEC's requirements; the major exceptions were capacity (10 rather than the 15 tons per hour requested), and storage design of the radiation source (the supplier was not prepared to change from dry to wet storage, but would guarantee safe operation in the event of electrical power failure for up to 24 hours). However, Techsnabexport was unable to agree to delivery earlier than 1988.

Expert Task 01 - Packaging of Stored Products

- H.A. HIGHLAND (USA) Sep 84 - Oct 84 26 days
  - To survey current in-country packaging materials, equipment, technology and usage;
  - To become acquainted with the dried fish industry, including drying, processing, storage, transportation and distribution for domestic wholesale and retail sales, and for export;
  - To provide guidance to develop packages that resist insect infestation after disinfestation by irradiation.

On arrival the expert found that the scientists of the IFRB had conducted preliminary and semi-practical tests to determine the insect resistance of packages made with some locally available materials. Sufficient information was available on radiation disinfestation of dried fish. The staffing was adequate, but equipment for preparing test packages was almost non-existent. Insect-rearing facilities were adequate to provide test insects if needed. Warehouses were available for conducting storage studies; a console irradiator was available for irradiating test packages.

With regard to local possibilities for producing insect-resistant packaging, the expert reported that ADAMJEE MILLS, the world's largest producer of jute sacking and carpet backing, produced polyethylene-coated jute. They could put additives in the polyethylene and could treat the jute directly with an insecticide. EAGLE BOX PACKAGING AND PROCESSING FACTORY produced shipping boxes, made of low-quality, domestically produced paper, however, the required resistance to abuse during shipment and storage

was being provided by a sewn jute over-wrap. PADMA PRINTERS, a printing plant well equipped with modern printing and slitting equipment, produced a variety of products, including small cartons for exporting frozen shrimp.

The traditional packaging for dried fish in domestic market channels consisted of jute, woven reed or bamboo, or corrugated boxes, none of these providing any protection from infestation, but rather tending to harbour insects. For export, dried fish was typically packed in 1-kg polyethylene bags, 20 of which were then placed in a large polyethylene bag which was placed in a carton. One or more cartons were then wrapped in a jute sack. Most dried fish for export passed through the ASADGANG WHOLESALE MARKET in Chittagong, the most frequent destinations being Hong Kong, Singapore, the Middle East, Great Britain, and Russia. Fish-drying season started in September/October, after seasonal flooding. Without exception everyone associated with dried fish marketing agreed that off-season (March through October) shipment of high quality dried fish would bring premium prices in both overseas and domestic markets.

To determine local practices related to insecticides, the expert visited two grain storage facilities and the Plant Protection Department. The storage facility at NARAYANGANJ (a river port) consisted of silos that were used for bagging rather than for storage. Therefore, grain seldom remained there long enough to require treatment for insects. The silos were equipped with sprayers to treat the grain on moving belts, but this equipment was not used. When necessary, the grain was fumigated with phosphine. At the TEJAGON CENTRAL STORAGE DEPOT, Dhaka, the stacks of bagged grain were routinely sprayed with folithion, malathion, methacrifos, or phoxim, and when necessary stacks were fumigated with phosphine or methyl bromide.

The Plant Protection Department provided chemical analytical services, but did not inspect or analyse food grains or seeds. However, their chemical analytical laboratory was adequately equipped to analyse for insecticides and had also analysed such commodities as jute, tea, and vegetables. Their services and co-operation would be required during investigations of insecticide-treated packages for dried fish, since IFRB did not possess this capability.

The expert's recommendations (IAEA-TA-2311) as supported by the TO:

1. GOVERNMENT: To support the use of protective packaging for dried fish, both for the export and domestic market by providing incentives, such as minimal import duties and restrictions on essential materials and equipment for manufacturing insect-resistant packages and packaging material.

2. COUNTERPART INSTITUTIONS: To evaluate the following package construction for resistance to insects: (a) Polyethylene-coated jute with heat-sealed seams; (b) Permethrin-treated polymer film as a bag in a box; (c) Permethrin-treated film heat sealed on the outside of a box; (d) Untreated film heat-sealed on the outside of a box; (e) Untreated polyethylene film as a bag in a box; (f) Permethrin-treated jute on the outside of a box.

3. AGENCY: To provide the Institute of Food and Radiation Biology with: (a) heat-sealer to seal polymer films; (b) heat-sealer to seal polyethylene-coated jute; (c) a gas-fired hot air gun to shrink over-wrap films on shipping cases.

Expert Task 02 - Design of Irradiation Facility

- P. LOAHARANU (IAEA) Dec 85 6 days

  - To meet with USSR experts to finalize the plans for siting the irradiation facility, and to discuss other outstanding matters.

Owing to visa problems, the three USSR specialists did not arrive. The expert held several discussions with the top level of management and senior scientists involved in the food irradiation programme of BAEC, as well as with the Chairman and Marketing Manager of the Bangladesh Export and Import Company (BEXIMCO), one of the largest producers and exporters of seafood and pharmaceutical products in the country. The management of BEXIMCO, which had followed the progress and development on food irradiation in recent years, agreed to provide from its own resources the necessary land and building to house the irradiator at its food processing complex in Chittagong, the largest deep-sea port in Bangladesh with a large number of food processing and storage facilities already in place. An agreement between BAEC and BEXIMCO to that effect was to be concluded during December 1985. The USSR Trade Mission, Dhaka, was informed of the site selection for the irradiator.

At the request of BAEC, the expert presented a one-hour seminar on "Progress of Food Irradiation" to officials of BAEC and representatives of local industry, FAO and USAID.

Visit by USSR Specialists -- January/February 1986

Three representatives of the supplier visited Bangladesh in January/February 1986 to firm up the implementation schedule, as follows:

2nd quarter 1986 -	Supplier to provide draft contract to IAEA for assembly supervision work.
3rd quarter 1986 -	Supplier to provide BAEC with technical design details, structural and radiation shield requirements.
4th quarter 1986 -	BAEC to approve design and obtain agreement of Bangladesh health authorities.
4th quarter 1986 -	Supplier's representatives to visit Bangladesh for agreement of technical design.
2nd quarter 1987 -	BAEC to provide structural design to supplier.
3rd quarter 1987 -	Supplier's representatives to visit Bangladesh for agreement of structural design.
October 1988 -	Delivery of radiation processing equipment.

Expert Task 02 - Design of Irradiation Facility

- A.M. DOLLAR (USA) Sep 86 8 days
  - To monitor the development on the construction for the USSR irradiator to be installed in an industrial complex in Chittagong;
  - To assist the local authorities in their R&D work on food irradiation, as recommended by an expert under project BGD/5/009 earlier in the year;
  - To assess the results of market testing of irradiated potatoes, onions and dried fish.

No report was submitted by the expert.

Expert Task 03 - Radiation Disinfestation and Packaging

- To assist local authorities in investigating the efficacy of radiation disinfestation and types of packaging required for long-term storage of irradiated dried fish, pulses and other stored products.

Between early 1987 and late 1990, five potential US experts (Mullen, Mitif, Brower, Dollar and Highland) were approached and accepted by the Government, but subsequently withdrew their candidature. The last (Highland) cancelled his mission for personal reasons on 16 October 1990, one day before it was scheduled to start. It was then agreed that Task 03 should be carried out by expert Giddings in conjunction with Task 06.

Expert Task 04 - Economic Feasibility Assessment

- R.B.H. WILLS (AUL) Jul 87 15 days

  - To develop a model techno-economic case study on viability of irradiating potatoes and onions in Bangladesh, including costs and benefits from farm to consumer or exporter. The case study should cover the various stages of post-harvest handling, irradiation, storage and transport. The disadvantages of not using irradiation (where losses occur) should be quantified.

In the course of his assignment, the expert visited (a) the BAEC Head Office in Dhaka for discussions on the aims of the mission and the general nature of research into fruit and vegetables in the Commission; (b) the IFRB laboratories in Savar for discussions on studies that have been conducted into the effect of irradiation on the post-harvest behaviour of potatoes and onions; (c) the SHYAMBAZAR WHOLESALE MARKET and the NEWMARKET RETAIL MARKET in Dhaka to examine methods of handling and assess the quality of potatoes and onions; (d) the growing district of JHITKA to examine facilities for the storage and transport of onions; (e) the CITY COLD STORAGE COMPANY, Dhaka, to examine facilities for the cold storage of potatoes and for discussions as to current problems and possible future developments in the industry.

The expert completed a detailed assessment -- for both potatoes and onions -- of prevailing conditions and practices with regard to marketing (immediate and delayed), storage (cool and ventilated) and resulting losses through sprouting, dehydration and rotting. He also advised on the advantages and economics (cost/benefits) of irradiation treatment for both vegetables.

The expert's recommendations (IAEA-RU-0939) as supported by the TO:

1. Irradiation of potatoes to inhibit sprouting prior to long-term storage at 12-15°C is considered a techno-economically feasible alternative to existing storage at 2°C, provided that the irradiator is conveniently located and fully used. Besides, irradiated potatoes are superior in organoleptic, processing and marketing qualities to the cold stored ones.

2. Further studies should be conducted at IFRB into the effectiveness of curing potatoes at high temperature and humidity as a precursor to irradiation. This would enable irradiated potatoes to be stored at ambient temperatures which could be commercially economic.

3. Irradiation of onions to inhibit sprouting prior to long-term storage at ambient temperatures appears to offer substantial economic and technical advantages for commercial use.

4. Further studies should be conducted on onions, to confirm the effectiveness of irradiation on wider range of cultivars and districts.

5. Establishment of warehouse facilities adjacent to the commercial irradiator at Chittagong for storage of onions and potatoes should be encouraged.

6. The availability of a commercial irradiator and associated warehouse facilities is required in Dhaka or close to the growing areas, to take full advantage of potatoes and onion irradiation.

Expert Task 05 - Design and Construction of Irradiation Facility

- V. STENGER (HUN) Jun 87 15 days

  - To assist local scientists/engineers in evaluating the mechanical design of the irradiator manufactured by the USSR, and to advise the civil engineers on the construction of the building to house the irradiator, as well as to advise on the calculation of the radiation shield to ensure adequate radiation protection of personnel.

The expert's visit was to coincide with a visit by the USSR engineers, initially scheduled for the 4th quarter of 1986, but after several postponements rescheduled for April 1987. The expert's assignment was planned accordingly, as it was essential that the supplier's engineers be available to answer questions concerning the mechanical design of the irradiator, the structural specifications for the building, and the radiation shielding requirements. Another delay by the supplier forced postponement of the expert's mission to 1 June. Unfortunately, the USSR engineers still did not arrive during the expert's mission,

even though he delayed his departure from Bangladesh for several days in the hope that they would arrive. Thus, the objectives of the mission could not be fully achieved.

The expert reported that preliminary specifications for the irradiator building had been received from the USSR supplier, and BAEC had initiated the structural design and general plant layout. However, the specifications were not sufficiently clear and detailed, and drawings and narrative did not always agree.

BAEC had formed a technical committee of highly knowledgeable engineers and scientists for design and implementation of the plant. Being familiar with USSR irradiator technology, the expert provided advice and assistance concerning technical irradiation parameters, shielding calculations, efficiency and throughput calculations, and arrangement of the plant and storage area.

The expert's discussions with the Technical Committee of BAEC included the following topics: (a) relationship of various source geometrics in relation to the products to be irradiated; (b) shielding calculations for the main walls, mazes for material transport and shipping containers; (c) shielding calculations for pool type storage; (d) calculations and evaluation of radiation efficiency and the capacity and the through-put calculations; (e) general arrangement of the irradiator; (f) storage area for irradiated and non-irradiated products -- medical and agricultural.

The expert's recommendations (IAEA-RU-1040) as supported by the TO:

1. It would be advisable for the Government to prepare a national plan for future expansion of irradiation technology. This plan should include the requirements of products to be irradiated in the future.

2. The counterpart institute should immediately recruit/designate operation and maintenance personnel for the irradiation facility being built at Chittagong, so that they get acquainted with the plant from the implementation stage.

3. Training of personnel in irradiation techniques, health physics and technological dosimetry should continue.

4. Mechanical, civil and electrical engineers, health physicists and food technologists connected with the project should make visits to USSR, Cuba and Portugal where similar irradiators from the USSR are in operation.

5. Detailed information should be obtained from the USSR supplier at an early date on: design, mechanical and electrical details, embedded items, general working drawings, operation manuals, operation conditions and flow diagrams for the whole process and the initial strength of the source and the maximum strength of the same.

6. The design of the irradiator should be such that source strength can be enhanced later on and subsequent reloadings can be done by using irradiator sources from countries other that the USSR as well. If necessary, a separate source container and a pool with handling facilities may be considered.

7. The Agency should provide assistance in implementing the above recommendations, as and when requested by the Government.

The Technical Officer considered the expert's visit to have been very useful, as he had been able to explain the structural design of the USSR irradiator, so that BAEC engineers were much better prepared for future discussions with the Soviets; however, the absence of the USSR engineers had severely hampered the mission. The Technical Officer was very concerned that a delay in the project of more than half a year had already occurred. Gammatech Ltd., the company formed by the BAEC and BEXIMCO for the establishment of the irradiation facility, was also very concerned at the delay, which could have a negative impact on the establishment of other irradiators by the company.

Significant milestones in the establishment of the irradiation facility -- up to the second visit by USSR specialist -- were:

September 1984	Contract signed with Techsnabexport, Moscow.
December 1985	Decision made to site the first facility in Chittagong.
Jan/Feb 1986	Visit to Bangladesh by supplier's representatives. Revised schedule agreed.
May 1986	Agreement concluded between BAEC and Bangladesh Export/Import Company (BEXIMCO) for formation of joint venture company, Gammatech Ltd. BEXIMCO to provide the necessary land at Chittagong and to finance the construction of the building and other infrastructure facilities at the site for installation of the irradiator.

October 1986	Techsnabexport submits technical documentation for structural design to BAEC (due 2nd quarter 1986).
November 1986	BAEC finds technical documentation inadequate to start civil engineering design. Requests additional information.
February 1987	IAEA requests Techsnabexport to respond to BAEC comments on technical documentation before visit of USSR specialists to Bangladesh now planned for April 1987 (visit was scheduled for 4th quarter 1986).
March 1987	BAEC forms Implementation & Technical Committee for establishment of the facility.
April 1987	Visit of USSR specialists postponed to June 1987. No response to questions on technical documentation yet.
June 1987	Agency expert Stenger visits Bangladesh to assist in evaluation of technical design and advise on structural design and radiation shielding. Mission to coincide with visit of supplier's representatives. USSR specialists fail to arrive.
August 1987	After several postponements, USSR experts arrive in Bangladesh to discuss and agree on technical design and on some additional equipment, instruments and materials to be supplied. No Agency representatives present.

Visit by USSR Specialists -- August/September 1987

Initially scheduled for the 4th quarter 1986, the USSR experts finally arrived in August 1987, to agree on the technical design of the irradiation processing equipment and to define performance specifications for the structural part of the facility. The supplier requested a concurrent visit by an IAEA expert, but the request was declined. An Agency expert (Stenger) had already visited the project in June 1987, and had briefed BAEC scientists and engineers on how to proceed in negotiations with the supplier. In fact, Stenger's mission was intended to coincide with the visit by the supplier's representatives; however, the USSR engineers failed to arrive, and a number of questions remained unanswered.

In view of the circumstances, the Agency should have been represented at this critical meeting, preferably by the Technical Officer. Key decisions affecting the outcome of the project were taken without Agency participation. Also, the meeting would have provided a rare opportunity for direct contact between the technical staff of the Agency and that of the supplier. Among other things, the Technical Officer could have started negotiations on the installation contract, or at least put forward the Agency's views regarding manpower and other requirements.

The late arrival of the USSR specialists resulted in a delay in the schedule of six to nine months. The following revised schedule was proposed by BAEC:

Aug/Sep 1987	Agreement on technical design.
October 1987	Shipment of embedded items (loading, ventilation, monitoring and communications equipment, dosimetry instruments).
November 1987	Completion of structural design.
December 1987	Agreement on structural design.
December 1987	Select contractor.
January 1988	Start construction.
January 1988	Arrival of embedded items.
September 1988	Complete construction.
October 1988	Arrival of plant equipment.
December 1988	Installation and commissioning.
January 1989	Trial run.

In a Desk Evaluation Review (DER) of the project carried out in late 1987, this schedule was considered to be very optimistic in view of past experience. The critical task was the construction of the building to house the radiation processing equipment which had to be ready before the equipment could be installed. The building was scheduled for completion in September 1988; however, it would not be possible to make a start on the building until a number of other tasks were completed, as stated in the DER :

> "The structural design of the building must be completed by BAEC. In order to complete this task, TENEX must supply drawings for installation of the overhead crane and other embedded equipment. These are due in the 4th quarter of 1987. At the time of writing (30 November 1987), they had not yet been made available.

After completion, the structural design must be submitted to the Bangladesh Nuclear Safety Commission for approval (the Commission is a unit of BAEC; therefore this should not present a serious problem).

BAEC is expected to provide the structural design, duly cleared by the Nuclear Safety Commission, to TENEX for approval during the 4th quarter of 1987.

TENEX specialists are scheduled to travel to Bangladesh in December 1987 for agreement on the structural design; however, the design must be complete and cleared by the Safety Commission, and agreement must be reached on a contract for installation of the processing equipment. TENEX has submitted a draft contract for the installation; however, the terms are not acceptable to the Agency. Revisions were proposed on 9 October 1987, but no reply has been received yet.

All of the above tasks are scheduled for completion in the 4th quarter of 1987. Obviously, some would have to be completed early in the quarter for all to be completed by the end of the quarter. At the time of writing (30 November 1987), none had been completed.

Once the structural design is complete, cleared and approved, tenders for construction must be called for, and the contractor must be selected.

Once the contractor is selected, construction can begin, but cannot be completed on schedule unless the embedded equipment items arrive at the right time. The schedule calls for shipment of these items in October 1987, and their arrival in Bangladesh in January 1988. At the time of writing, orders had not been placed. Quotations from suppliers in the USSR were being invited.

Once the building is ready, the process equipment, scheduled to arrive in October 1988, can be installed and tested, assuming that it has arrived in time. If the completion of construction is delayed beyond this date, as seems likely, shipment of the process equipment must be deferred."

Nevertheless, in view of the significant technical progress and the agreement concluded with BEXIMCO, the DER concluded:

"The ingredients for a major success are present. Fulfillment depends upon careful management of all elements by the parties involved, closely supported by the Agency. A successful first installation is crucial to the future of food irradiation in Bangladesh."

The cautions expressed earlier in the DER subsequently turned out to have been only too well founded, as described in detail and in chronological order in the following paragraphs.

Visit by USSR Specialists -- April/May 1988

Discussions were held with BAEC engineers, based on the detailed structural drawings mailed by BAEC to Techsnabexport already in December 1987. Drawings of the embedded details for installing the overhead travelling crane, and drawings of the items of stainless steel for the storage and ventilation ducts located below zero level were provided to BAEC.

The Soviet team agreed that they would provide to the BAEC team of engineers shortly expected to visit Moscow, a format and materials for preparing a preliminary Safety Analysis Report, as required by the Nuclear Safety Committee of Bangladesh for the issuance of the construction permit of the plant. It was also agreed that every two years the irradiation source would be refurbished so as to keep its strength of 110 000 curies, and that at the end of 15 years the spent source would have to be returned to Techsnabexport for ultimate disposal. For both refurbishment and ultimate disposal of the spent source separate contracts would have to be signed with Techsnabexport.

It was further agreed that installation of the equipment would start after completion of the construction works, including completion of the radiation chamber and rooms, ventilation, lighting and supply of 16 pig iron blocks for source shielding. For acceptance of the civil construction works by Techsnabexport, BAEC would contact Techsnabexport two months before their completion. BAEC would provide the necessary tools and materials for the installation work.

In view of the delay of the visit -- agreement on the structural design of the facility was initially scheduled for December 1987 -- the work schedule was revised as follows:

May 1988	Approval of design for structural part
June 1988	Arrival of embedded items
July 1988	Start of civil construction
4th quarter 1988	Arrival of plant equipment
January 1989	Completion of construction
February 1989	Certification by Techsnabexport on civil construction
March 1989	Start of installation and commissioning of equipment
July 1989	Trial run

During a visit to the project in June 1988, the Project Officer (Bautista) was handed yet another revised schedule, which had also been communicated to Techsnabexport, proposing to start construction upon return of the BAEC team of engineers from their visit to Moscow in September, as follows:

Civil construction of project building:
- Start - September 1988
- Complete - April 1989

Shipment of source and equipment:
- Shipment from USSR - December 1988
- Arrival Chittagong - March 1989

Assembly of source and equipment:
- Start - April 1989
- Complete - July 1989

In meetings with representatives of Techsnabexport at Agency Headquarters on 23 and 25 August 1988, it was agreed that: (a) Arrangements would be made to request the FAO representative in Bangladesh to monitor progress of work on the irradiation facility, to ascertain the number of specialists required for commissioning, and to act as representative of the IAEA during discussions between Techsnabexport and BAEC; (b) Techsnabexport would submit a list of specialists and skilled labour needed for the commissioning, to be relayed to the counterparts, so as to allow enough time for them to provide some manpower requirements locally; (c) A training programme for 9-10 people, constituting the permanent staff of the irradiation facility (manager, repair and maintenance engineers, operational staff), would be prepared and implemented by Techsnabexport, consisting of 2-3 weeks of training in various institutes in Moscow and similar food irradiation facilities; target date: February 1989.

In September 1988, Gammatech informed the Agency that construction could not start as foreseen, since the embedded items had only been shipped in late June, and were not expected to arrive in Chittagong before October 1988. (In fact, they only arrived in November 1988). Moreover, the BAEC team of engineers upon their return from Moscow were suggesting certain minor changes in the civil construction design of the building, which needed to be integrated into the final drawings. After selection of the contractors, and return to normalcy after the recent devastating flood, Gammatech hoped to start civil construction at the earliest, trying to keep the completion time, July 1989, nearly the same.

Expert Task 90 - Consultants

- P. LOAHARANU (IAEA) Jan 89 7 days
  - To assess the progress and development on the construction of the demonstration irradiator for food processing provided by the Agency.
  - To give lectures to local scientists on the status of acceptance and application of food irradiation.

The expert visited the IFRB for informal discussions with senior scientists on recent developments and future trends of food irradiation and possible assistance in this field to be requested from the Agency. At the Bangladesh Standard and Testing Institute (BSTI) discussions were held on matters related to control aspects of food irradiation in Bangladesh. The expert reported that BSTI was responsible for implementing national standards for food and industrial goods -- some 80 products were controlled by BSTI, including frozen shrimps, frog legs, dried fish, tea, jute, etc. -- and inspecting these products to ensure compliance with standards. BSTI, together with BAEC, had implemented a national standard for some 11 irradiated items in 1982.

The expert gave a one-hour seminar on "Recent Developments on Food Irradiation with Special Emphasis on Possible International Trade in Irradiated Foods", attended by some 80 scientists/officials of BAEC, Gammatech, BSTI, and a few representatives from the local mass media.

A meeting was held with BAEC and members of the Project Implementation Committee (PIC) of Gammatech Ltd., to discuss the organizational set-up and management plan. The training schedules of scientists/official of BAEC, BSTI and Gammatech discussed with the expert are shown under "Training". The schedule of construction, installation of irradiation facilities and expert services allocated to the project was also discussed and agreed upon by PIC, as follows:

1989:	Jan - Feb	Evaluation of tenders for construction and awarding of contract.
	Mar - Sep	Civil construction of irradiation facility, associated laboratories and administrative office in Chittagong.
	Oct - Dec	Installation of irradiator by the USSR engineers and test run.

1990:	Jan	Commissioning and inauguration of facility One man-month of expert services on radiation measurement, dosimetry and process control (Stenger).
		Convening of ICGFI Workshop on Economic Feasibility of Food Irradiation (2 weeks) for junior scientists/ officials from Asian countries.
	Feb - Mar	Expert services on irradiation technology, including GMP on specific food items (Giddings/Farkas).

In May 1989, the Agency was informed that Techsnabexport was ready to ship the irradiation facility; the sources to follow after installation. BAEC was requested by the Agency to confirm readiness to accept equipment, and if not, to inform on new schedule. In reply, BAEC requested immediate shipment since, although the building was not ready, proper arrangements could be made for storage. BAEC would inform Techsnabexport when to ship the sources after installation.

In June 1989, Techsnabexport requested that BAEC immediately confirm their readiness to receive the gamma-sources not later than May/June 1990; otherwise they could only be shipped in 1991. BAEC considered May/June 1990 reasonable and the requested confirmation was given.

In July/August 1989, in conjunction with home leave, the Technical Officer (Ahmed) reviewed the project and reported that construction work had not been started since the project still had to be cleared by the Nuclear Safety Committee and the Pollution Control Board. In addition, an administrative clearance by the Ministry (of Education) was required for the bank loan. In a meeting with the Secretary, Division of Science and Technology, Ministry of Education, the TO was assured that every step would be taken for the timely implementation of the project, for which Gammatech proposed a new schedule:

Sanction of loan by bank	-	July 1989
Completion of legal formalities and start of civil construction	-	August 1989
Arrival of machinery at site	-	October 1990
Completion of civil construction	-	January 1990

Erection and installation of machinery and trial operation	-	February 1991
Commercial operation	-	March 1991
Shipment of machinery from USSR	-	Early September 1989
Shipment of sources	-	November 1989

In July 1990, BAEC informed the Agency that the consignment of the machinery (45 cases) had arrived in Chittagong, but that clearance was held up for want of negotiable shipping documents. Techsnabexport was requested to provide by courier service the original bill of landing plus invoice and packing list. The shipment was cleared through customs in August 1990.

Expert Task 08 - Review Mission

- M. AHMED (IAEA) Jul 90 - Aug 90 6 days
  - To review the up-to-date status of the project;
  - To evaluate the utilization of the assistance already provided;
  - To assess future needs of the project;
  - To fix up the date for the commissioning of the facility provided under the project;
  - To advise on the utilization of the facility after completion.

The Technical Officer found that the construction work of the facility was progressing satisfactorily. The foundation of the heavy construction part of the building, i.e. source storage, shielded walls, etc., was complete. The TO was assured by the site engineer that the irradiation building would be completed by November 1990. He was told that 72 tons of construction materials from the USSR had arrived at the Chittagong port which, in the absence of the bill of lading, could not be cleared from customs. This, apparently, had happened before.

The TO also visited the warehouse of the contractors where the construction material would be stored. Gammatech had already received the generator from the supplier and was advised to check equipment and construction materials as soon as they were received. Gammatech expected the arrival of the Soviet experts to examine the irradiation building in November 1990.

The equipment and materials already received under the project were being utilized for R&D in food irradiation: pilot-scale irradiation studies on packaging, disinfestation and storage of dried fish and pulses; sprouting inhibition of potatoes and onions, and storage; test marketing and consumer acceptance of the above-mentioned irradiated products.

The TO's recommendations:

1. The Agency should closely monitor the construction schedule of the facility in order to see that the project is completed without further delay.

2. The Agency should inform Techsnabexport to provide the bill of lading before the arrival of the materials in Chittagong port.

3. The Agency should provide a certificate or request the supplier to confirm that the source capsules and source containers are produced as per international standards. The unsigned certificates provided by the supplier are not acceptable to the Bangladesh National Radiation Safety Committee.

4. The Techsnabexport should provide the Bangladesh authorities with biodata and passport details of their experts at least 90 days before their assignment in order to facilitate their visas.

In October 1990, BAEC requested Techsnabexport to defer the arrival of the installation experts (planned for 12 November) by eight weeks, in view of construction delays "due to circumstances beyond control". In January 1991, BAEC let the Agency know that they were ready to receive the Soviet specialist in the middle of March 1991, for acceptance of the gamma-facility building.

No information could be found in the files as to why this visit did not take place.

In May 1991, BAEC informed the Agency that most of the crates containing the equipment for the irradiation facility had been dampened by saline water and rain water during a recent cyclone and tidal bore. Some damage had also been done to the building (centering and shuttering works for the loading and unloading zone). The cobalt source had not been affected as it had been safely stored in the reactor hall at Savar. BAEC requested Techsnabexport experts to examine the damage.

Visit by Russian Specialists -- June 1991

A Committee was set up, including the three specialists from Techsnabexport and three representatives from BAEC, to inspect the damage. The Committee found that 85% of the equipment for the irradiation facility had been affected by seawater and rainfall, resulting in corrosion developed in various metallic parts, terminals of electrical equipment and in a number of mechanical equipment. A detailed list was prepared, describing each damage and dividing the equipment into the following types on the basis of the degree of damage caused by the cyclone:

1. Equipment which did not need attention or further work;

2. Equipment which needed maintenance attention, such as cleaning, painting, opening, assembling, adjustments and minor repair work (e.g. change of lubricant, greasing, etc.);

3. Equipment which was not usable and needed replacement.

The Committee agreed that a group of three experts from Techsnabexport should visit Bangladesh for checking and repairing the equipment prior to installation and commissioning of the facility. Equipment which could not be repaired had to be replaced either before or in the course of the proposed visit. The following construction, fabrication and installation work had to be completed by the end-user before the final installation could start:

- Installation, testing and documentational formalities of systems and facilities, such as the crane in the source room, ventilation, electrical supply and water supply;

- Construction of shielding blocks and transport to the site of their installation.

According to the information provided by the end-user, the work related to structure and civil construction had to be completed not later than October 1991. A revision in the schedule for the completion of civil construction and the start of installation would necessitate a revision of the equipment, and possible replacement of certain components, and additional work. Techsnabexport was invited to undertake the necessary repair of the equipment and, when the time came, to proceed with its installation; to certify acceptance of the civil construction; and to prepare schedules for installation, testing and commissioning of the facility in accordance with the design specifications.

Expert Task 06 - Irradiation Technology

- o To assist BAEC in commissioning the USSR-manufactured irradiator and to advise and train the counterparts in the management and process control of a semi-commercial-scale cobalt-60 food irradiation facility through lectures and practical demonstrations.

Under this task, two months of the services of a one-year, Vienna-based consultant, G.G. GIDDINGS (USA), recruited to assist with the implementation of food irradiation projects, were charged to the project, using one month of the US extrabudgetary contribution (May 1991) and one month of Regular Programme funds (October 1991). The consultant visited the project for two weeks in August 1991 -- outside the periods charged to the project -- to: (a) Advise IFRB on disinfestation and packaging of irradiated foods; (b) Give lectures and consult on medical product radiation sterilization; and (c) Visit the Chittagong irradiator construction site and evaluate progress.

A seminar on "Radiation Processing, Including Food Irradiation", presented by the consultant at BAEC Headquarters for the senior staff of BAEC and interested industrialists, including BEXIMCO, as well as the press, resulted in positive articles in the local press.

At the IFRB, the consultant was impressed by the breadth and diversity of the R&D activities going on at the Institute and the high calibre of its scientific staff. Of particular interest were two applied, practical food-related successes, involving a small shallot-onion and chipping potatoes, where irradiation was permitting extended storage at ambient (15°C) temperature, instead of at 0-4°C, thus resulting in considerable energy saving. The consultant found that the Gammabeam 650 used for this research was already increasingly unable to meet the growing need for gamma irradiation, and it remained to be determined to what extent the demonstration gamma irradiator being installed at Chittagong would be able partially to alleviate this growing need. He thought that in all probability a higher-capacity irradiator would ultimately be essential for the Dhaka area as well, in particular in view of on-going tests involving chicken feed and broilers, sun-dried swordfish and mackerel, and irradiated gram seed and mung.

With regard to the situation at the construction site in Chittagong, the consultant reported that the concrete-shielded irradiation room, including the cobalt-60 storage pool, had been completed prior to the April 1991 cyclone-tidal wave and had, therefore, merely

encountered some flooding in the absence of any structural damage. The partially completed materials handling/warehousing building, on the other hand, had received substantial structural damage, including the blowing away of the partially completed roof, setting back the already considerably delayed overall completion date. At the time of the consultant's visit, the building appeared to be roughly half completed and, in the opinion of the consultant, should be finished within a few months.

The consultant further reported that the storage area providing temporary housing for the Soviet hardware and other items to be installed in the completed structures had been blown apart and flooded, and the crated equipment submerged in seawater from the tidal wave. Despite the report by the three-man team of Techsnabexport that had already visited the site to ascertain the damage, the consultant thought that -- in view of the complexity of the irradiator, having so many electro-mechanical components and automated functions -- the true extent of any damage would not be fully known until the facility was assembled and fully functionally tested for operational integrity. An especially rigorous and thorough commissioning of this particular irradiator was required, following painstaking examination and testing of functional components before and during installation, to assure that all was in proper working order.

> The consultant's conclusions and recommendations:
> "The food irradiation research and development programme of the BAEC has long been among the very best in the region in terms of its focus, the manpower devoted to it and the competence with which it has been carried out and its results. So, the expert has nothing specific to offer by way of recommendations in that regard beyond a "keep-up-the-good-work"! The GAMMATECH irradiator project is, of course, well behind the original completion schedule due mainly to the slowness of the construction contractor's work, and climatic conditions, including the devastating April 1991 cyclone-tidal wave impact on the site itself, and on the work. As pointed out in the body of the report, the latter can only be expected to exacerbate "normal" installation and commissioning start-up problems. BEXIMCO appears to be the ideal industrial irradiator joint venture partner (with the BAEC) for the GAMMATECH Ltd. irradiator in the Bangladesh context, in that it is managed by two proven entrepreneurial brothers and an able staff, including GAMMATECH Managing Director, Dr. M.M. Hossain. Also, its business ventures include some very promising industrial irradiator applications, including frozen frog legs/shrimp, and health care products. BEXIMCO would appear to be an excellent joint venture partner for a future Dhaka industrial irradiator as well, which may rest largely with the success of the Chittagong irradiator, thus its importance. So, recommendations are as follows:

(1) GOVERNMENT/BAEC/BEXIMCO/GAMMATECH: "Keep up the good work" in completing the GAMMATECH irradiator and its successful operation in every respect, including operational and as a first-in-the-country commercial/demonstration unit.

(2) FAO/IAEA: Especially in view of the facts that (a) the irradiator mechanism to be installed at Chittagong is a relatively complex automated system, and (b) while still in the shipping crates it sustained the impact of the April cyclone plus tidal wave (i.e. was submerged in seawater), it is deemed to be of the utmost importance that the supplier check and test all components and the entire assembled system before, during and after installation to assure that all is functioning according to specifications or that corrective action is completed before turning the facility over to the BAEC-BEXIMCO. Specifically, it is strongly recommended that FAO/IAEA have a team of Techsnabexport technician carefully inspect the site, and especially all of the equipment components, and repair or replace damaged or defective ones in advance of installation."

In August 1991, the Technical Officer (Ahmed) also visited Dhaka in conjunction with home leave and was briefed on the latest status of the project in a meeting with BAEC and Gammatech. He was told that 90% of the building facility was completed. BAEC expected the arrival of the Soviet team for the commissioning of the facility by the middle of October 1991. Before the commissioning, BAEC requested the Agency to send Soviet experts to check some of the equipment and material affected by the cyclone. BAEC felt that, if during the commissioning some of the equipment were not useable, the progress of work might be hampered and it might be possible that commissioning would be stopped altogether. In order to address this problem beforehand, the TO recommended that two Russian experts who were associated with the construction of the facility should visit Bangladesh before commissioning.

There is no information in the files as to whether this visit actually took place.

In January 1992, the Agency was asked by BAEC to request Techsnabexport to send the selected three specialists as soon as possible since "the building is ready for installation and commissioning of the irradiation plant".

Visit by Russian Specialists -- March/April 1992

The visit of the Techsnabexport specialists -- starting in mid-March and planned for a period of 2.5 months -- was, at the request of BAEC, intended to recondition the radiation process equipment and to help in completing the construction of the buildings for this facility. In a meeting with BAEC at the start of the visit, it was agreed that the construction work would be finished by the time the reconditioning of the equipment was completed. It was further agreed that, if the structural part was not finished by mid-April 1992, the Techsnabexport specialists would take a break and would not call up the installation team until the structural part of the facility was completed.

In a "Memorandum on the Status of the Structural Part of the Gamma Facility and the Results of Reconditioning of the Radiation Process Equipment" prepared on 18 April 1992, the Techsnabexport specialists stated that, since the structural part of the facility had not been completed, they were taking a break. The bulk of the reconditioning work had been completed. There remained the simple jobs of cleaning and painting the metal structures. The equipment to be replaced would be delivered by the Techsnabexport installation team.

With regard to the structural part, the Memorandum stated:

"As of today (18 April 1992), the following jobs (in accordance with the contract and the construction requirements) have to be completed before the installation work can start:

- The beam crane in the irradiation chamber should be made ready for operation (connection of power supply, testing, etc.);
- The concrete floors in the process room, operator's room and diesel generator room should be completed;
- A place for the irradiator drive should be built (above the irradiation chamber); stairs with protective guards should be constructed;
- Rooms with air-conditioners and showers should be built;
- The finishing work for all rooms in the facility should be carried out (plastering, painting and whitewashing);
- The supports for the conveyor in the process room should be installed;
- The ventilation equipment should be installed;
- The electricity supply lines to the facility should be completed and the power supply panel installed;
- The diesel generator should be installed and started up;
- The water supply system should be installed;

- The equipment, tools and personnel for installation of the radiation process equipment should be made ready (the list of the necessary equipment and tools, together with the number and category of personnel, has been handed over to the customer [BAEC]).

After finishing the above jobs, BAEC should send the request for the services of the supplier's specialists to Techsnabexport.

Comments:

- o The work on the structural part is proceeding slowly.
- o Further prolonged delay in finishing the structural part may make it necessary to recondition the equipment again, cause further decay of the radiation sources and impair the facility's parameters.
- o Our daily reminders about the need to speed up and complete the construction jobs are not understood by the people concerned, who attribute the delay to numerous problems.
- o It is necessary to ensure a more clear-cut, flexible and responsible organization of work by Gammatech."

A meeting was held on 20 April 1992 at IFRB in Savar, between the IAEA Project Officer, who had visited the project site on 18 April 1992, the Director of the International Affairs Division of BAEC, the Director General of AERE, the Director of IFRB, and the Project Counterpart. The IAEA Project Officer pointed out that, although IAEA had been informed by the Commission both in November 1991 and in February 1992 that the construction was complete, a lot of work still needed to be done and that under these circumstances the current mission of the Russian specialists had been bound to fail. The success of the project would very much affect future IAEA technical assistance to Bangladesh in this field. All efforts must be undertaken to complete the following work as per schedule:

1. Completion of all construction work, including floor and control room (first floor) within one month.
2. Electricity, ventilation, water supply, etc. must be completed by the next two months.
3. All equipment must be cleaned and checked by local engineers immediately.

For timely completion of the work, the Managing Director must be immediately transferred to Chittagong for direct supervision of the work. Otherwise it was feared that the work may not be completed in the near future.

In August 1992, the Agency received a letter from BAEC, countersigned by Gammatech, stating that all construction work had been completed, and requesting that Techsnabexport installation specialists arrive at the earliest opportunity for installation and commissioning of the irradiation facility.

In order to avoid another premature mission by Techsnabexport specialists, the Agency requested confirmation of the above by the Director, International Affairs Division, BAEC, who on 12 September 1992 confirmed by fax:

"1. The overhead crane has been installed and electrically treated. The Managing Director of Gammatech gave assurance that necessary wiring (permanent), greasing and fitting of gear oil are being done and will be completed in 2/3 days.
2. The concrete floors in the source room, diesel generator room and the loading/unloading zone have been completed.
3. The room for the irradiator drive system has been completed.
4. A room with air-conditioners and shower has been made already (in the adjacent BEXIMCO fish-processing building).
5. Finishing works, e.g. plastering, painting, white-washing, etc., are completed.
6. Conveyor supports in the process room have been provided.
7. The ventilation equipment have been installed.
8. Power supply to the facility has been provided.
9. The diesel generator has been installed and can be operated by direct connection. But it cannot be made operational through the control as there are discrepancies in the working drawings furnished by the suppliers. This part can be done by the Russian experts.
10. There is already a water supply connection (although, as stated by the Managing Director, the same has to be transferred in the name of Gammatech). This, according to him, will not hamper the cooling devices, as the required connections have been made and the motor has been installed. He has taken the responsibility to complete the work.
11. It is stated by the Managing Director, Gammatech, that equipment, tools and personnel are ready for continuation of work."

Following a request by DIR-RIFA, the above statement was confirmed by the FAO Representative in Dhaka, who informed the Agency on 24 September 1992 that "all the necessary jobs in accordance with the contract and the construction requirements are done and ready for the installation work to begin".

In summing up the importance of project BGD/5/010 for the future, the Technical Officer in November 1992 stated:

"A food irradiation facility is expected to be commissioned at the beginning of 1993. It is a demonstration facility which will treat potatoes, onions, garlic, pulses and dried fish on a semi-commercial scale. The facility is being established in Chittagong, the largest port city in the country, which is also the centre of the production of dried fish and fishery products. Recently, Bangladesh has established a laboratory under the technical assistance of the Agency to determine agrochemical residues in food (BGD/5/014). Laboratory examination of dried fish has revealed that it contains excessive residues of chlorinated hydrocarbon (i.e. DDT). DDT is banned in Bangladesh for use in food and agricultural products. As there is no available method to control insects in dried fish, traders unscrupulously and injudiciously use this pesticide. There is a great need to immediately use irradiation as an alternative to pesticide treatment. The facility is ideally located to treat dried fish commercially. Warehouses have been built and other infrastructure is available as it is located in an industrial area.

Over 50 000 tonnes of fish are dried in Chittagong and channeled through this city for internal marketing and export. Chittagong also controls the marketing of dried fish produced in the interior of the country. Besides, 80% of the frozen sea food is exported through Chittagong port. It is the second largest city in the country with a population of over one million. It has large storage facilities for potatoes, onions, garlic, ginger, pulses, etc. for internal consumption. An economic feasibility study conducted in Bangladesh in 1984 showed that a commercial irradiation facility could run profitably in Chittagong. The profitability calculations are based on irradiation of 6500 tonnes of dried fish, 3000 tonnes of frozen fish and fishery products, 25 000 tonnes of potatoes, onions, garlic, ginger, etc. Indicated quantities are easily available in the city for irradiation treatment. A commercial facility with a nominal loading of 200 kCi of cobalt-60 with an automatic conveyor system can treat the above-mentioned quantities when utilized at around 65% of its capacity. In order to reach break even situation for revenue and costs, a 50% capacity utilization is adequate for such facility. In addition to commercial viability of the project, other benefits from this facility are saving in energy, reduction in post harvest food losses, better quality of foods, extension of storage life, improved distribution and marketing of these treated products. Besides, it will be used as an alternative treatment of pesticides as mentioned above.

In order to evaluate the economic feasibility of irradiation of dried fish, frozen fish and fishery products, potatoes, onions, garlic, ginger and pulses, a mission will be needed to examine the potential for scaling-up of the existing irradiator or establishing a new commercial irradiation facility in Chittagong."

In his comments to this summary, the Project Officer stated that, in his opinion, the facility should first be commissioned (it was already late), logistics of carrying out food irradiation should be established, and cost economics of operations for a trial period of, say, one year investigated, before fielding a new economic feasibility mission.

Visit by Russian Installation Specialists -- November 1992/March 1993

Installation work started in mid-November 1992 and progressed apparently without further difficulties.

On 21 March 1993, BAEC informed the Agency that the installation of the gamma irradiator at Chittagong had been completed. The Government had consented to inaugurate the plant on 30 March 1993.

LIST OF EQUIPMENT PROVIDED			
ORDERED	SUPPLIER	ITEMS	SHIPPED(S) RECEIVED(R)
84-09-24	TENEX, USSR	Large multi-purpose irradiation facility equipped with 200,000 Curies of Co-60 and consisting of: irradiator; irradiator drive; radiation source storage; loading mechanism; automatic conveyor; hanging containers; container rotation system; reloading mechanism; loading and unloading stations; control panel; switch board; shielding device; dosimetry control panel; relaoding control unit; sliding platform; blocking interlock device and assembly components.	90-08-28(R)
85-03-26	Fisher, USA	Freeze drying unit; bacteriological incubator; laminar flow bench	86-02-03(S)
85-03-26	Baird, UK	Fume hood	85-07-30(S)
86-01-31	Malow, USA	Heat sealers	86-03-18(S)
86-10-17	Fisher, USA	Freeze-drying unit accessories	87-02-05(S)
87-02-19	Fisher, USA	Heating and drying oven; electronic analytical balance; pH meter; incubator	87-08-12(S)
87-02-19	Nissei, JPN	Air-conditioning equipment; dissecting microscope; moisture tester	87-04-08(S)
87-03-16	Varian, SWI	Spectrophotometer; chart recorder	87-07-08(S)
88-01-18	TENEX, USSR	Loading, monitoring and communications equipment	88-11-11(S)
88-04-15	TENEX, USSR	Ventilation system; dosimeter	90-11-01(R)
88-04-15	TENEX, USSR	Accumulator	89-08-01(R)
88-08-29	TENEX, USSR	Overhead travelling crane with load capacity of 3 t	90-08-15(S)
88-12-05	SOVELECTRO, USSR	Generator	90-05-01(R)
89-08-02	TENEX, USSR	Fire detection system	90-11-01(R)
89-10-12	TENEX, USSR	Radiation detectors and counters	90-05-18(S)
91-01-11	Fisons, UK	Water bath; bacterial colony counter; analytical balance; bench top centrifuge; incubator; microscope; spectrophotometer (uv-vis); sterilizer	91-07-02(R)
92-02-20	TENEX, USSR	Electronic components	92-11-30(R)

Training

The following requests for training of the local staff, included in the project request forms submitted between 1982 and 1986, were supported by the Technical Officer:

- One fellowship and one scientific visit in food storage and packaging (no duration specified);
- A scientific visit to pilot and/or industrial irradiators (1 month);
- A fellowship in radiation decontamination of spices (12 months);
- A scientific visit to commercial food irradiation facilities in Europe: BEL, HUN, NET (1 month);
- A fellowship in food irradiation microbiology (12 months);
- Two fellowships in process control and quality assurance of food irradiation (3 months each);
- A fellowship in radiation disinfestation of stored products (12 months).

Additional recommendations with regard to training were subsequently made by one of the project experts and the TO, following their visits to the project:

Stenger, Jun 87:

- Training of personnel in irradiation techniques, health physics and technological dosimetry should continue.
- Mechanical, civil and electrical engineers, health physicists and food technologists connected with the project should make visits to USSR, Cuba and Portugal where similar irradiators from the USSR are in operation.

Loaharanu, Jan 89:

- Two engineers and three operators from Gammatech should be trained in Portugal in addition to the USSR. This should be arranged during the last quarter of 1989, immediately prior to the completion of the demonstration irradiator in Chittagong.

- The Plant Manager of Gammatech should be knowledgeable on food quality, dosimetry and radiation protection. The candidate selected by Gammatech should be nominated by BAEC to attend a formal training programme designed specifically for plant managers of irradiation facilities available for processing foods (Course organized by the International Consultative Group on Food Irradiation [ICGFI] under its "Food Irradiation Process Control School [FIPCOS] in Montreal, 12-23 June 1989).

- There is a need to train one food inspector on proper control procedures of food irradiation in accordance with the principles of the Codex General Standard for Irradiated Foods. A BSTI food inspector stationed in Chittagong will be nominated to attend ICGFI's training programme designed for food control officials under FIPCOS, which will be held at IFFIT, Wageningen, in September 1989.

- The IAEA has received a number of nominations for fellowships and scientific visits of scientists and engineers from BAEC on the assumption that most of these candidates will be transferred to Gammatech. However, no decision has as yet been made on whether any of these candidates will be transferred to Gammatech or not. BAEC to advise the IAEA, with a minimum of six months in advance, on the actual training of the new list of candidates for training on operation and maintenance of the irradiator.

The following training has been provided:

- **Project-funded (PF) and Project-related (PR) Fellowships and Scientific Visits**:

BGD/83VB (PR)	AMIN, Md. Ruhul (IFRB)	
	Scientific Visit, Sep/Oct 84	
	HUN - Central Food Research Institute, Budapest	12 days
	NET - IFFIT, Wageningen	19 days
	Food Irradiation (5H)	
	o To get acquainted with the aspects of the irradiation of food products at pilot-scale operation.	
BGD/8319 (PR)	ISLAM, Md. Shamsul (IFRB)	
	Type II Fellowship, Sep 84/Mar 85	
	NET - IFFIT, Wageningen	6 months
	Food Irradiation (5H)	
	o Parameters relevant to pilot-scale operations for the irradiation of potatoes and onions.	

BGD/8320 (PR)
SEAL, Dakshina Ranjan (BAEC)
Type I Fellowship, Nov 83/Aug 84
USA - ARS, Savannah — 9.5 months
Food Preservation (5H)
- Development of suitable packaging and storing conditions to prevent insect reinfestation of foods in conjunction with a food irradiation programme.

BGD/8321 (PR)
NILUFAR, Khatun (IFRB)
Type I Fellowship, Oct 86/Oct 87
AUL - Queensland Dept. of Primary Industries, Brisbane — 12 months
Food Preservation (5H)
- Entomological aspects of radiation disinfestation of food, including the preservation of reinfestation by use of suitable packaging materials.

BGD/8410 (PF)
RAHMAN, Muhammad Saifur (IFRB)
Type I Fellowship, Aug 85/Aug 86
JPN - JAERI, Takasaki Radiation Chemistry Research Est. — 12 months
Food Irradiation (5H)
- Practical training in food irradiation, including pilot-scale irradiation of potato and onion.

BGD/8429 (PR)
HOSSAIN, Md. Mosharraf (IFRB)
Type I Fellowship, May/Nov 87
JPN - National Food Research Inst., Yatabe — 6 months
Food Irradiation (5H)
- Research training in food irradiation, including packaging of irradiated foods and pest disinfestation.

BGD/8519 (PR)
RAHMAN, Rezaur (IFRB)
Type I Fellowship, Jan 87/Jan 88
IAEA - Seibersdorf Laboratory — 12 months
Food Irradiation (5H)
- Research in radiation disinfestation of food.

BGD/8737 (PR)
AHMAD, Mushtaque (BAEC)
Scientific Visit, Aug/Sep 88
USSR - All-Union Inst. of Radiation Technology, Moscow — 19 days
CUB - Research Inst. for the Food Industry, Havana — 6 days
Radiation Engineering (4L)
- To discuss engineering details and requirements of a Soviet-type commercial gamma irradiator.

BGD/8738 (PR)
HABIBUDDIN, Muhammad (AERE)
Scientific Visit, Aug/Sep 88
USSR - All-Union Inst. of Radiation Technology, Moscow — 19 days
CUB - Nuclear Res. Inst., Gamma Irrad. Lab, Havana — 6 days
Radiation Engineering (4L)
- To discuss engineering details and requirements of a Soviet-type commercial gamma irradiator.

BGD/8740 (PR) BHUIYA, Mohammad Abdul Dayen (IFRB)
Scientific Visit, May 89
USA - USDA Agricultural Research Service, Savannah 6 days
CAN - Canadian Irradiation Centre, Montreal 6 days
Food Irradiation (5H)
- To visit establishments engaged in large-scale packaging and disinfestation studies of irradiated foods.

BGD/8810 (PR) NAHAR, Gul (IFRB)
Type II Fellowship, Apr/Oct 90
USA - ARS, Gainesville 6 months
Food Irradiation (5H)
- Training in food irradiation with emphasis on radiation disinfestation and packaging studies.

BGD/8811 (PF) ISLAM, Md. Saidul (IFRB)
Type I Fellowship, Mar 90/Jan 91
PHI - Nuclear Research Institute, Diliman 10 months
Entomology (5D)
- Training in food irradiation with emphasis on rearing and disinfestation of fruit flies.

BGD/8813 (PR) RASHID, Harun-Or (IFRB)
Type I Fellowship, Sep 89/Sep 90
JPN - JAERI, Takasaki Radiation Chemistry Research Est. 12 months
Food Irradiation (5H)
- Training in food microbiology.

BGD/8825 (PR) AMIN, Md. Ruhul (IFRB)
Type II Fellowship, Nov 90/Feb 91
USA - National Bureau of Standards, Gaithersburg 3 months
Radiation Processing (8H)
- Training in application of the reference and the routine dosimetry techniques for high-doses, such as fricke, ceric-cerous sulphate and perspex.

BGD/8826 (PR) SIDDIQUI, Md. Anwar Kamal (IFRB)
Scientific Visit, May 89
HUN - Agroster Joint Irradiation Dev. Co., Budapest 6 days
NET - IFFIT, Wageningen 4 days
BEL - Inst. Nationale des Radioéléments, Fleurus 2 days
Food Preservation (5H)
- To get a practical experience on food irradiation processing.

BGD/8833 (PR)
MATIN, Muhammed Abdul (IFRB)
Scientific Visit, Mar 89
GDR - Central Inst. for Isotopes & Radiation Res., Leipzig 7 days
HUN - Agroster Joint Irradiation Dev. Co., Budapest 6 days
NET - IFFIT, Wageningen 4 days
Food Irradiation (5H)
- To get a knowledge on commercial processing of roots and bulb crops, including marketing and consumer's acceptance aspects.

BGD/8836 (PR)
HOSSAIN, Md. Abdul (IFRB)
Scientific Visit, May 89
HUN - Agroster Joint Irradiation Dev. Co., Budapest 6 days
NET - IFFIT, Wageningen 4 days
BEL - Inst. Nationale des Radioéléments, Fleurus 2 days
Food Irradiation (5H)
- To become acquainted with a commercial processing of food irradiation facility, with special emphasis on good manufacturing practice and process control.

BGD/8901 (PR)
HAQUE, Md. Muzammel (AERE)
Type I Fellowship, Dec 89/Jan 90
USSR - All-Union Inst. of Radiation Technology, Moscow 21 days
Food Irradiation (5H)
- On-the-job training on engineering aspects of the building of the irradiation facility.

BGD/8902 (PR)
AHMED, Salah Uddin (AERE)
Type I Fellowship, Dec 89/Jan 90
USSR - All-Union Inst. of Radiation Technology, Moscow 21 days
Food Irradiation (5H)
- On-the-job training on electrical engineering aspects of the irradiation facility.

BGD/8903 (PR)
CHOWDHURY, Manzur Ahmed (AERE)
Type I Fellowship, Dec 89/Jan 90
USSR - All-Union Inst. of Radiation Technology, Moscow 21 days
Food Irradiation (5H)
- On-the-job training on mechanical engineering aspects of the irradiation facility.

BGD/8904 (PR)
HAQUE, Mahbubul (AERE)
Type I Fellowship, Dec 89/Jan 90
USSR - All-Union Inst. of Radiation Technology, Moscow 21 days
Food Irradiation (5H)
- On-the-job training on overall structural design of the facility, including repair and maintenance.

BGD/8905 (PR) HOSSAIN, Md. Mostak (AERE)
Type I Fellowship, Dec 89/Jan 90
USSR - All-Union Inst. of Radiation Technology, Moscow — 21 days
Food Irradiation (5H)
- o On-the-job and practical training on the dosimetry and radiation protection aspects of the irradiation facility.

BGD/9058 (PF) SIDDIQUI, Md. Anwar Kamal (IFRB)
Scientific Visit, Sep/Oct 90
IND - BARC, Bombay — 12 days
Radiation Processing (8H)
- o Practical training in quality control through GRP and GMP.

- **Participation in Regional Group Training Events:**

RAS/5/017 Regional Study Tour on Food Irradiation Development
12 - 25 Apr 86, China
- o To promote the exchange of information between scientists and officials in the region with regard to research and development leading to practical application on food irradiation.

HOSSAIN, Mir Mosharraf — 14 days
MATIN, Muhammed Abdul — 14 days

RAS/5/020-002 Regional Workshop on Techno-economic Feasibility of Using Electron Beam vs. Isotopic Sources of Radiation for Food Processing
22 Oct - 2 Nov 90, Japan
- o To expose participants to different aspects of certain irradiation facilities and their economic use; to facilitate the consideration of the introduction of electron machines in RCA countries.

AHMED, Salah Uddin — 12 days

RAS/5/020-003 Regional Workshop on Public Information of Food Irradiation
27 - 31 May 91, Thailand
- o To provide factual information concerning the safety, benefits and limitations of food irradiation.

KHAN, Ahsan Ali — 5 days
RAHMAN, M. Gaziur — 5 days

RAS/5/020-006 Regional Workshop on Food Irradiation Process Control
31 Aug - 11 Sep 92, People's Republic of China
- To follow the principles of the codes Standard and Code of Practice and Good Manufacturing Practices in the irradiation facilities.

AMIN, Md. Ruhul 12 days

RAS/8/061-011 Regional Training Course on Industrial Radiation Sterilization - Quality Control and Sterility Assurance
5 - 16 Oct 87, Thailand
- To provide basic training and experience in microbiological quality control practices in industrial radiation sterilization of disposable medical products.

AMIN, Md. Ruhul 12 days

RAS/8/061-020 Regional Training Course on Radiation Engineering - Gamma Radiation Facilities
21 Nov - 2 Dec 88, India
- To provide background and fundamental knowledge in gamma radiation technology, with emphasis on its application in the field of radiation processing.

HAQUE, Mahbubul 12 days

RAS/8/061-027 Regional Training Course on Industrial Radiation Sterilization Selection and Compatibility of Materials
5 - 16 Dec 88, India
- To provide basic training in quality control of materials used for production and packaging of medical items sterilized by radiation.

CHOWDHURY, Najmul Alam 12 days

RAS/8/061-048 Regional Training Course on Industrial Radiation Sterilization - Quality Control and Sterility Assurance
13 - 24 Feb 89, Thailand
- To provide basic training in microbiological quality control practices in production and industrial radiation sterilization of disposable medical products.

CHOWDHURY, Najmul Alam 12 days
SIDDIQUI, Md. Anwar Kamal 12 days

RAS/8/061-073 Regional Training Course on Industrial Radiation Sterilization - Quality Control and Sterility Assurance
14 -25 May 90, Thailand
- To provide basic training in microbiological quality assurance practices in production and industrial radiation sterilization of disposable medical products.

FATEMA BEGUM, Fatema 12 days

RAS/8/061-074 Regional Workshop on Industrial Sterilization of Medical Products - Regulatory Aspects
28 - 30 May 90, Malaysia
- o To review existing regulations and guidelines concerned with industrial sterilization of medical products - Current Practices and Future Needs.

AMIN, Md. Ruhul — 3 days

RAS/8/062-033 Regional Workshop on Radiation Sterilization of Pharmaceuticals and Drugs
25 - 29 Nov 91, India
- o To review present status of radiation sterilization for pharmaceutical products, including guidelines for establishing feasibility of radiation treatment of pharmaceuticals and regulatory aspects.

SHAMS, Mustafa Khalid — 5 days

ACCOMPLISHMENTS

As of 1 March 1993, project BGD/5/010 has provided a total of 5.5 man-months of expert services, equipment valued at $1 029 102, as well as two fellowships and one scientific visit for a total of 22.5 months of training abroad. In addition, some 80 man-months of training was provided through project-related fellowships and scientific visits and through participation in regional group training events.

A key achievement early in the project was the conclusion of an agreement with a major commercial organization, the Bangladesh Export/Import Company (BEXIMCO). Under this agreement, a joint venture company, Gammatech Ltd., was formed to establish, operate and manage irradiation plants in Bangladesh. Ownership of Gammatech is vested in BAEC (51%) and BEXIMCO (49%). BEXIMCO has provided land at Chittagong, financed the construction of the building, and contributed to local costs up to an agreed maximum. Once the facility is operational, BEXIMCO will deliver its produce to the plant, pay a processing fee to Gammatech, and market the treated products. Other customers may also contract for the irradiation processing services to be provided by Gammatech. The significance of this arrangement is the involvement of the food industry, necessary to exploit the technology to the benefit of the country.

General public acceptance of irradiated foods, essential for these plans to succeed, has already been achieved through test marketing of various items of food and through a public information programme and seminars held for interested industrialists and the press. There is a keen interest in the process among entrepreneurs. Through BAEC, the programme enjoys strong support by the Government, including the funding of staff, facilities and equipment, and conclusion of the agreement with BEXIMCO. Legal clearance has been obtained for irradiation as a process for treatment of food and agricultural products, and a large number of food items have been approved for treatment by irradiation.

Excellent progress has been made on technical aspects, including identification of appropriate products, product mix, volumes, densities and required dosages, and development of suitable packaging materials, methods and storage standards. Assisted by the expert advice, training and equipment provided by the Agency under its technical co-operation programme -- as well as by contracts awarded under the Agency's research

contract programme -- IFRB has achieved a high level of expertise in food irradiation technology; according to the Technical Officer, among the highest in the world. Between 1987 and 1990, ten scientific papers and publications on food irradiation, prepared by the Institute, appeared in journals and national and international conference proceedings.

Through the acquisition of a USSR irradiator, the Agency has succeeded in making use of a substantial amount of non-convertible currency. However, a serious drawback, particularly in the early stages of the project, was that communications with the USSR supplier were not always satisfactory and that the visits to the project site by the USSR specialists were frequently delayed, partly owing to visa problems (e.g. through repeated last-minute changes in the composition of the team). Thus, a number of scheduled meetings with Agency staff/expert missions to the project could not take place, to the detriment of smooth and timely implementation of the project. Key decisions were taken without Agency participation and repeated revisions of the implementation schedule were required. By mid-1987, the project was already nine months behind schedule, and the delays continued. Drawings of the embedded details for installing the overhead travelling crane, and drawings of the items of stainless steel for the storage and ventilation ducts located below zero level were provided to BAEC only in April/May 1988, although arrival of the embedded items had been planned for January 1988 in the revised schedule agreed during the August/September 1987 visit by the supplier specialists. The embedded items finally arrived in Chittagong in November 1988. This resulted in a new schedule with postponement of the start of construction from January 1988 to early 1989. At this stage, a further delay occurred since the project still had to be cleared by the National Safety Committee who required confirmation by the USSR suppliers, not yet provided, that the source was fabricated according to international standards. After confirmation was obtained, construction work finally started in August 1989 (20 months after it had been initially foreseen) and, by mid-1990, was reported to be progressing satisfactorily, if slowly. The bulk of the equipment had also arrived. Acceptance of the gamma-facility building by USSR specialists was foreseen for March 1991.

In April 1991, disaster struck with a cyclone and tidal bore which heavily damaged some still not quite finished buildings and soaked the stored crates of equipment with salt and rain water. As a result of this natural catastrophe, completion of the project was delayed by another two years.

Installation of the equipment and source could finally be started in November 1992 and has now been completed. The facility will be inaugurated on 30 March 1993.

Economic feasibility studies are at present being undertaken for a second facility, planned by BEXIMCO for Dhaka. Other, commercially-funded plants may follow, based on the experience gained at the Chittagong demonstration facility.

According to the Interim Project Implementation Report submitted in September 1992, some additional equipment (personal dosimeters and survey meters) and short-term training for project manager/operators and operation and maintenance staff would still be required. Plans up to 1995 for continued research and development work at IFRB, in co-operation with Gammatech, include:

Technology Transfer:

- Disinfestation and economic feasibility study of food and agricultural products and dried fish;
- Enhancing hygiene and improved 'storageability' of dried fish and other agricultural products;
- Sterilization of medical products;
- Shelf-life extension and elimination of pathogens from fish and fishery products.

Process Control:

- Dose distribution/dose uniformity ratio in food items in commercial packages;
- Operation of the radiation facility in compliance with the recommended code of practice;
- Irradiation and product handling in accordance with ICGFI provisional guidelines.

Market Testing of Irradiated Food and Agricultural Products:

- Promotional test marketing on different food items in usual trading channels;
- Transportation trials and evaluation of quality of products in and outside Bangladesh;
- Dissemination of information on safety and benefits of irradiated food and other agricultural products.

III

FINDINGS

As already stated in the 1987 evaluation of the project, the general goal is to increase the availability of food to the population of the country, to reduce dependence upon imported food, and to increase earnings from food exports. In pursuit of this general goal, the main objective of the project is to establish a semi-commercial irradiation facility to demonstrate the efficacy and profitability of food irradiation in reducing the high storage losses of food, particularly of economically important items, such as potatoes, onions, and dried fish. Successful demonstration of irradiation technology in food disinfestation and preservation on a semi-commercial scale was expected to lead to the establishment of a network of commercially-financed irradiation facilities.

The objectives of project BGD/5/010 have been only partially achieved. An effective transfer of food irradiation technology has taken place, and a highly qualified cadre of scientific and technical staff has been built up at IFRB and Gammatech, able to put into practice the technology acquired, once the facility has been commissioned.

Excellent work has been done on the public information sector, stimulating the interest of private enterprise in the technique and showing promise for commercial funding of additional plants, once the Chittagong facility has demonstrated the economic advantages of the process on a semi-commercial scale. With general public acceptance already achieved through test marketing, and with the existing strong Government support, no problems are expected for marketing the irradiated food items once the plant will be in operation.

Economic profit for the plant is expected in the treatment of dried fish, potatoes, onions and pulses. In particular, the facility will be able to produce about 6500 t of irradiated, non-toxic dried fish per annum, in replacement of dried fish formerly treated with pesticides and showing high toxic levels.

Installation of the irradiation facility, initially planned for 1987 and subsequently confirmed by the suppliers for 1988, has been delayed by five years, mainly because the building to house the equipment could only be completed in late 1992. A number of factors have contributed to this construction delay in the earlier stages of the project, e.g. unsatisfactory communication links with the USSR suppliers of equipment, who rarely replied promptly to a request by the Agency or BAEC, or both; the repeated failure of their representatives to reach the project site in time for meeting with Agency staff or experts, to discuss and decide upon important issues; delayed and unclear specifications as well as contradictory construction designs. In addition, shipments of equipment arrived late and/or not accompanied by negotiable shipping documents, resulting in further delays before the equipment could be cleared through customs.

Failing to reach Bangladesh in time for Loaharanu's visit in December 1985, the USSR specialists did arrive in January 1986; failing to meet Stenger in June 1987, they did visit the project in August/September 1987. In both cases, the earlier Agency visits had been for the purpose of meeting with the supplier representatives to discuss and decide upon important issues, and in both cases the Agency decided not to send a second mission. Agency guidance during these two delayed visits by the USSR specialists might have contributed to avoiding some of the subsequent delays.

The recurrent difficulties and delays through not requesting and obtaining visas for the installation specialists in a timely fashion, a problem not unique to the project on hand, may have been avoided if an attempt had been made early in the project to appoint a fixed team of specialists for the required periodic visits and to obtain visas for multiple entries of this team into the recipient country.

It is, at this point, idle to speculate what the effects of the cyclone/tidal bore disaster in April 1991 would have been, had the project been implemented according to schedule. Certainly, the damage would not have been as heavy if at least the construction of the buildings had been completed by early 1991. Thus, the repeated smaller delays caused by the supplier have contributed to the ultimate, major delay caused by the natural catastrophe.

The advantage of the project utilizing a significant amount of non-convertible currency has been almost entirely offset by the difficulties encountered with the suppliers of the NCC equipment. It would not be appropriate for the Agency to consider any future co-operation with these suppliers, unless ensured of a major improvement and a more competitive approach in their business policy and practices.

On the other hand, Gammatech seems to have been not too effective during the actual construction stage, and progress was slow. More pressure applied by BAEC and BEXIMCO to speed up the construction work might also have minimized the effects of the April 1991 disaster.

In view of the long delay and of the excessive damage done to both building and equipment, it would be prudent to send an expert -- after commissioning of the facility and before closing the project -- to go over the entire facility to determine possible shortcomings within the period of warranty, and to check whether all equipment intended for the Chittagong plant is in place and in good working order.

With the inauguration of the plant on 30 March 1993, the ingredients for a major, if considerably delayed, success are still present. Following its commissioning, the first months of operation of the facility on a semi-commercial scale will be crucial to the future of food irradiation in Bangladesh. At this stage, Gammatech still has to prove its effectiveness under semi-commercial operating conditions.

Continued Agency support of the programme through a small follow-up project may be required for additional training; for refurbishing of the source; for occasional expert advice; and to ensure periodic progress reports, furnishing the Agency with details on the experience gained, which could subsequently be used to advantage in other, similar projects.

IV

RECOMMENDATIONS

(1) After considerable delays in its implementation, project BGD/5/010 is nearing completion. Following inauguration of the irradiation facility on 30 March 1993, and before closure of the project, it is recommended that the funds remaining under the project be used to provide the additional equipment and training requested by the counterpart, and to field a final expert mission to go over the entire facility to determine possible shortcomings within the period of warranty, and to check whether all equipment intended for the Chittagong plant is in place and in good working order.

(2) To ensure the viability of the programme and its impact on the country's economy, it is essential that the Agency continue to monitor the activities of the programme, and of the demonstration facility set up under the project, over the next few years. To this end, it is recommended that the Government request, and the Agency approve, a small follow-up project in support of the plant's activities under semi-commercial operating conditions.

(3) Gammatech Ltd. have not been too effective during the construction of the building to house the irradiation facility and still have to prove their efficiency and effectiveness under semi-commercial operating conditions. It is recommended that BAEC and BEXIMCO closely observe and supervise Gammatech's activities over the next few years.

(4) In view of the difficulties encountered with the suppliers of the irradiation facility, it is recommended that the Agency consider further co-operation with them only if a major improvement and a more competitive approach in their business policy and practices could be ensured.

(5) To avoid delays through recurrent visa problems on future multi-year projects, providing large items of equipment and requiring repeated visits to the project by the suppliers' staff, it is recommended that the Agency, at the time the contract is concluded between supplier and recipient, request the supplier to appoint a fixed team of specialists for the required periodic visits to the project, and request both parties to explore the possibilities for obtaining visas for multiple entries of this team into the recipient country.