NUCLEAR APPLICATIONS IN INDUSTRY

RCA INDUSTRIAL PROJECT (1982-991)

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INTRODUCTION

The project on the Industrial Application of Isotopes and Radiation was carried out under the Regional Co-operative Agreement (RCA) for Research, Development and Training Related to Nuclear Science and Technology in Asia and the Pacific 1982 to 1991. The project was underpinned by UNDP funding and supplemented by extra-budgetary financing mostly from Japan, Australia and IAEA but with some contributions from India and China. There were also major inputs from the 'in kind' contributions made by the participating Member States. Altogether some US$ 14.3 million has been identified as the total contribution to the support of the activities over these ten years, as shown below:

Fund Source	Financial Contribution US$	
	Phase I (1982-1986)	Phase II (1987-1991)
UNDP	4,455,375	3,270,000
IAEA	565,2[illegible]0	540,579
Australia and Japan	1,226,[illegible]20	[illegible].184,45[illegible]
"In-Kind" contributions	61[illegible],[illegible]02	1,428,00[illegible]
Total	6,859,42[illegible]	[illegible]423,035
GRAND TOTAL	US$ 14,[illegible].46[illegible]	

This project has been carried out at a time of enormous economic activity and expansion for the Asia Pacific countries. Growths in Gross Domestic Products in most cases have averaged around 8% over these 10 years and in some years have been well into double figures. In the midst of such a boom, with economies making the transition from a largely agricultural to an agro-industrial bias, the relevance of nuclear technologies to the needs of industry have been put to the test especially since the broadly claimed development objectives of the project were the creation of economic and social benefits to the developing countries of the Region. The areas of impact for the project were identified as:

- increased use of modern (nuclear) technology in the regions industries
- improvement in the competitiveness of manufactured products through better quality, higher productivity and lower costs
- increased Utilization of raw materials in high consumption industries (in some countries giving an effective saving in the levels of imports of these materials)
- improvement in the efficiency and productivity of industrial processes (giving effective savings in electrical energy usage)

and it was expected that economic gains would be achieved over a 5 to 10 year period and further long-term benefits would be realized.

The challenge has been to demonstrate that these goals were achievable and to convince the emerging industries that such applied nuclear technology could provide the bridge to the industrial and commercial advances they were seeking.

The Industrial project stated in 1982 following pre-project work beginning in 1979 and was completed at the end of 1991. The four sub-project areas of:

- tracer technology in industry
- radiation technology
- non-destructive testing (NDT)
- nucleonic control systems

targeted different aspects of the total industrial needs. Each of the four sub-projects has had different goals, different impacts on industry and the economy. These will be reviewed to show how they have impacted on the region's industries.

Analysis of the feed-back from RCA Member States on national investments in Nuclear Technology over the period 1987 to 1991 has revealed that at least US$ 190 million has been invested by government and private sector organizations, of which only 21% came from Governments, the bulk of the investment US$ 150 million was made by the private sector.

Not all the four technologies have the same requirements for capital investment. Tracer technology and NDT do not require large purchases of expensive equipment even for fully equipped laboratories. Here the knowledge, experience and skill of the operators is the critical factor for the promotion and progression of the technologies into the industrial sector. On the other hand, Radiation Technology and Nucleonic Control Systems have to have large capital investments to pay for large radiation sources, specially constructed buildings to house these sources, industrial standard dlectronic and computing equipment, and the like. The operators of these installations have to be well trained with highly site specific skills in contrast for Tracers and NDT there is a requirement for wider ranging skills.

As far as the technologies selected for investment, Radiation Technology accounted for US$ 117 million and Nucleonic Control Systems US$ 71 million.

Tracer Technology in Industry

Tracer technology has found many applications in modern industries, particularly in investigations of dynamic systems. A wide range of features can be studied such as leaks, blockages, mixing efficiencies and flow behaviour. All such measurements can provide important information about the industrial process under investigation allowing faults to be diagnosed, process efficiencies to be measured and flow regimes to be characterized.

Tracer technology has become well developed in a number of countries and service companies have been set up around the world to exploit the commercial opportunities.

In the Asia Pacific region only Australia, and India had extensive experience in this technology and China had developed expertise in specific areas. Only limited work had been carried out by some of the other countries. The general regional situation in 1987 could be categorized as:

- insufficient qualified manpower
- insufficient infrastructure and resources for providing services to industries
- inadequate appreciation of some sectors of industry of the technology and its cost/benefit
- a lack of knowledge of problems in specific industries.

Two parallel approaches were used to try to address these problems. One was a programme of demonstrations and seminars for technologists and industrial personnel to create awareness of the technology and its technical and economic benefits. The other was a programme of training to develop and strengthen the knowledge and experience of the scientists and engineers who were designated to undertake this work nationally. Each participating Member State nominated a team of at least four scientists/technologists to form national tracer groups to be responsible for the technical back-stopping and development of this area of technology.

Looking back over the five year period from 1987 to 1991 the various inputs into these two programmes can be readily quantified. (Because of the much higher level of development of this technology in India and China, the data does not include any participants or activities in htese countries). Ten demonstrations took place in six countries Bangladesh (2); Indonesia (1); Republic of Korea (1); Philippines (2); Sri Lanka (1); and, Thailand (3). At the national level 8 seminars and the 10 demonstrations were given to 364 engineers, scientists and industrialists while at the regional level 42 scientists were trained at four regional training courses, which were held in India, Malaysia, Pokistan and Indonesia.

All these activities have had a measurable impact in the region. The demand for technology is increasing and are shown by the number of enquires reaching the national nuclear research institutes (NNRI). Seven participating countries have established National Tracer Groups (NTG). Four NTGs in Indonesia, Malaysia, Pakistan and the Philippines have had sufficient basic training and are now providing limited services to industry and related areas. The major obstacle to overcome is a lack of self-confidence in the team members of the NTGs who are making the difficult transition from working in the environment of a research laboratory in their own field of expertise to having to be competent in a wide range of industrial technology and operate under close scrutiny in an industrial environment. This problem can only be addressed through "hands on" experience.

Commercial service companies have been set up in Australia, India and Malaysia to cater for the general regional needs. In India and China some companies have their own groups to exploit the technology specifically for their own needs.

Non-Destructive Testing (NDT)

The use of NDT is wide-spread throughout the industrialized world. As the name implies, the use of this technology allows a piece of equipment or a part to be tested for defects without it being affected by the testing process. Often NDT can be applied to the investigation of complex structures without the need to strip them down and this has lead to its ready acceptance in a wide range of industries such as: heavy metal industry; electrical power plants; nuclear industry; chemical and petrochemical industry; civil engineering; and, transportation.

NDT has become one of the most effective means of quality control in industrial production, construction work, maintenance, and safety testing.

NDT involves a number of technique and its increasing importance has fuelled the need for well-trained, well-qualifies staff. In the industrialized countries there is a three level categorization of the skill levels:

Level 1-for operators or technical assistants

Level 2-for technicians

Level3-for engineers and technologists.

In the region it was recognized that there were insufficient numbers of qualified and certified NDT practitioners at all three levels in the basic techniques of: radiography; ultrasonics; eddy current; dye penetrant; and, magnetic particles. Further, at the national levels there were deficiencies identified in training capability, training guidelines, standards for certification (harmonized with international standards) and national organization. While at the regional level there was no scheme for regional qualification and certification of NDT personnel.

The strategy for addressing these problems in this project started with the adoption of the draft guidelines for the qualification and certification of NDT Personnel that had been developed by the International Committee for NDT and the International Standards Organization (ISO) for the development National Certification Schemes, DIS 9712. Standard syllabi in regional and national training were adopted through the use of the IAEA TECDOC 407 'NDT Training Guidelines in Non-Destructive Testing Techniques'. In order to be able to develop national training and national certification schemes there had to be sufficient numbers of qualified NDT personnel at level 2 and so it was essential to train a core of personnel who could in turn train sufficient numbers of level 2 personnel in the 5 basic NDT methods. Regional and national training was therefore a priority. A strong regional network of national co-ordinators was also necessary for monitoring the progress and developing the national infrastructures.

Within the region China, India, Republic of Korea and Singapore were well-developed in NDT and their contributions have not been included in the analyses of the activities carried out between 1987 and 1991.

At total of 1,445 personnel were trained to level 2 and level 3 in 15 regional and 63 national courses for all the five basic methods (except level 3 eddy current). This large number of trained personnel are now able to provide the services previous imported from overseas. This has created a spin off benefit of employment and business opportunities for those trained.

As far as the national organization of NDT is concerned all participating countries have formed National Co-ordination Committees, which are the precursors to national NDT societies, and five countries Bangladesh, Malaysia, the Philippines Sri Lanka and Thailand have established national NDT Societies. The region is becoming more self-reliant and Bangladesh, Malaysia, Indonesia, Pakistan and the Philippines have certainly attained partial self-reliance.

Radiation Technology

The use of radiation technology in industry has been introduced in many developed countries and it has been shown that many advantages can be derived such as:

- savings in energy requirements
- savings in raw materials
- new or improved product quality
- added value to indigenous raw materials
- elimination of harmful chemical residues in treated products
- reduction in emission of environmentally hazardous materials.

These types of saving are also important to the developing countries.

In the past five years, four specific technologies have been considered. The first is **Radiation Vulcanization of Natural Rubber Latex (RVNRL).** The use of carefully controlled amounts of radiation has been shown be able to vulcanize rubber, giving a product free form sulphur residues and nitrosamine. The development of this material has had its genesis in the regional has involved a significant amount of effort from RCA Member States. The problems that have had to be addressed have been both technical and promotional. Initially rubber latex technologists and product manufacturers were inadequately informed on the potential uses and benefits of RVNRL and the technical/economic benefits needed to be demonstrated. The rubber technologists had not got adequate experience to allow them to consistently produc RVNRL and the technology needed to be optimized to suit locally produced latex.

Over the past five years there has been significant progress. As far as the commercial exploitation of the RVNRL, Japan is already producing protective gloves, laser balloons, drainage bags and catheters on a commercial scale. Indonesia has had test trials of surgical gloves, condoms and thread and Viet Nam has also produced surgical gloves and balloons under commercial conditions. Thailand has produced test products such as examination gloves, balloons and baby teats under manual fabrication conditions and for the examination gloves this has also been carried out using industrial scale machines. Indonesia is making RVNRL for their home market and has begun exporting RVNRL to producers in Europe.

Full scale production facilities are now being seen as a requirement for the region and India is about to commission a full scale RVNRL irradiator.

The development of RVNRL has made a new material available for world markers. It is providing the possibility of high quality nitrosamine free latex for the hygienic based products industries and this could revolutionize the applications and range of their manufacturing.

Radiation curing has been an established technology in developed countries countries through which coatings can be cured on a variety of substrates such as paper, plastics and metals and especially wood. Within the region there was a need to promote this technology because of an inadequate level of awareness of the technological viability and economic benefits of radiation curing among the potential users.

The strategy to address this problem used a combination of training courses and seminars and 'hands on' access to a pilot-scale electron beam irradiation facility set up in Jakarta. Limited production-scale runs of parquet flooring and wood panels have been undertaken.

In six National and one Regional Executive Management Seminars 289 senior management personnel were informed about the radiation curing technology. 42 scientists and engineers were trained in three Regional Training Courses. The awareness level in the region has now been improved and expansion of the technology rests on the development of a consumer demand for the higher quality products and the establishment of economic feasibility studies to support investment.

Radiation Cross-linking applications in the wire and cable industry, although well developed in industrialized countries, were not well known to industrial personnel in the region. There was a need to promote this technology to industrialist and this was done using a demonstration facility in China and through Executive Management Seminars (EMS) and training events. Some 343 industry and related personnel participated in 6 EMSs and a futher 107 were trained at either the three Regional or the one National Training Course.

China, Republic of Korea and India have made substantial investments in this technology, for example, in the Republic of Korea US$22.1 million was invested in this technology between 1987 and 1990.

The final technology in this field incorporated in the project is **Radiation Sterilization**. The development of this technology had been limited because of two main factors: inadequate promotion of the benefits and opportunities for the use of Good Manufacturing Practice and Good Radiation Practice among the owners, operators and regulations of the established industrial radiation sterilization facilities; and the relative high cost and limited availability of single-use disposable medical products inhibited the expansion of this market even though the health care benefits were known. In the developed countries that had invested in the establishment of this technology, there had been a great social impact in the health care sector.

During the past five years a combination of Regional and National training events was used to promote this technology. Some 438 people were trained in 10 Regional and 11 National Training Courses. 421 participated in 11 National Executive Management Seminars and 58 participated in 4 Regional Workshops. During that time there were investments in new facilities in China, India, Indonesia, Malaysia and Pakistan and existing facilities in Bangladesh and Viet Nam were adopted to accommodate radiation sterilization. Out of 160 commercial installations worldwide, 25% are installed in developing countries with the RCA Member States being the most advanced in this aspect.

Nucleonic Control Systems

The use of nucleonic control systems in the industrialized countries is well established and has been applied to industries such as paper, steel, aluminium, plastics, glass, textiles, rubber and metal coating. The nucleonic gauges are non-contact and able to determine "on line" such diverse measurements as density, thickness, moisture content, coating thickness, level and chemical composition. Furthermore these results are instantaneously determined so that the analysis information can be feedback immediately to enable the manufacture of the product to be optimized. This "real-time" analysis can have significant benefits over other conventional methods and lead to higher quality products with better utilization of energy, raw materials and industrial plant and minimization of wastage.

The major efforts were expended in NCS applications in the paper and mineral industries. In 3 national and 2 regional seminars over the past 5 years 251 scientists, technologists and industrialists participated and 17 were trained in one Regional Training Course and one Regional Workshop. These regional and national programmes in the paper industry have been very effective and the use of NCS in medium and large scale plants is routine. There has been substantial market penetration in the past five years with 158 NCS systems installed at paper mills compared with 10 in the previous five years. The next challenge is to satisfy the small scale paper plants and China, India and Japan have all been developing this technology.

The penetration of the NCS technology into the steel industry has been strong especially in India and China where there are large integrated steel works.

Over the whole spectrum of applications in NCS to the steel, mineral, coal and paper industries there were 81 scientists and engineers training in Regional Courses since 1987. Over the same period 634 senior decision makers participated in national promotional activities.

Conclusion

The IAEA/UNDP/RCA Industrial project has involved Member States in the Asia Pacific Region in a programme to increase the use of nuclear techniques in the industries, which has increased the level of awareness amongst scientists and engineers, technologist and decision makers and provided significant training to scientists and engineers enabling them fulfil a role in technical back-stopping at a national level in the fields of:

- tracer technology
- non-destructive testing
- radiation technology
- nucleonic control systems

and through them achieve improvements both in the product and the productivity in the past 5 years some US$ 7.42 million were spent on promotion and creation of awareness of the technologies. 67 regional training events had 801 participants and 139 national events had 4701 participants. 385 experts and consultants were also involved in the project work or as lecturers as well as Agency technocal staff.

The success of the project required a high level of regional co-operation and collaboration as well as the appropriate technology. The very strong foundation for the regional co-operation and collaboration that has been developed in Asia and the Pacific through the Regional Co-operative Agreement founded in 1972 and continued to this date, has greatly assisted in the progress and development of this work.