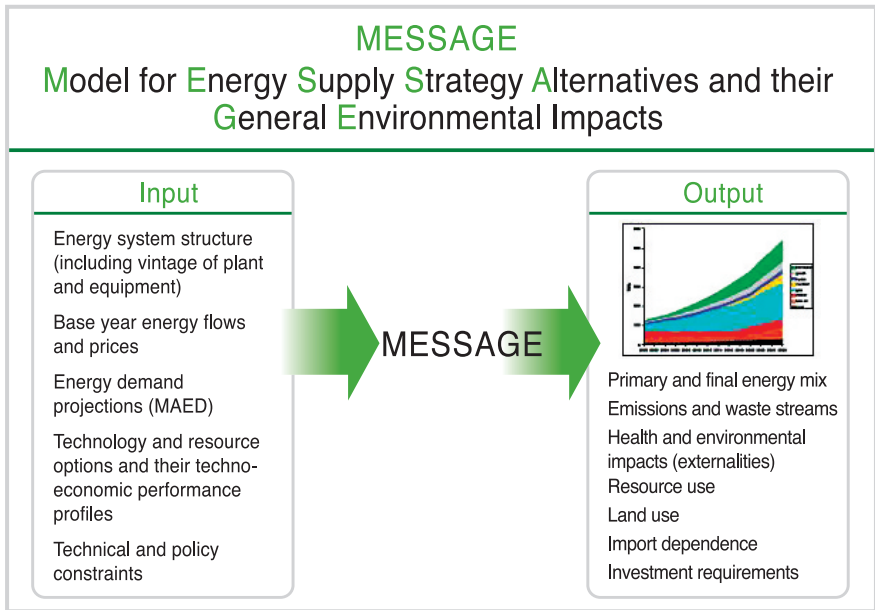


Enhanced Energy Analysis and Planning Capabilities

Energy is an indispensable input for economic growth and social development, underpinning basic needs and services and a critical factor in production in virtually all sectors of the economy. Unfortunately the production and utilization of energy have a wide range of environment impacts which have concomitant costs at the local, regional and global levels. The provision of adequate energy services at affordable costs, in a secure and environmentally benign manner and, in conformity with a country’s social and economic developmental needs, necessitates that significant consideration be given to energy technologies that are compatible with sustainable development.

The fast economic and population growth in the RCA Member States has caused drastic increases in energy demand. A major issue for many Member States is to undertake energy planning while considering associated factors such as developmental needs, supply security, costs, and environmental impacts so that these can be included in any decision-making processes. As a consequence, they formulated a series of regional projects to build capacity on energy issues, with a focus on electrical energy; address environmental concerns; and, provide information for decision making, as needed. All aspects were undertaken under the common objective of strengthening sustainable development.

These projects have been implemented and have achieved their primary goals. As a result, and within the scope of the project, the participating RCA Member States are better able to elaborate sustainable energy strategies; conduct national studies to set up sustainable energy development taking account of the role of nuclear power and other energy options; and, provide recommendations for appropriate actions consistent with national objectives for sustainable development. Important elements in the training were the development of energy scenarios under possible climate change control regimes for the post Kyoto period and the use of IAEA’s analytical tool MESSAGE (Model for Energy Supply Strategy Alternatives and their General Environmental Impacts) for formulation and evaluation of sustainable energy strategies to address climate change issues.



MESSAGE combines technologies and fuels to construct so-called “energy chains”, making it possible to map energy flows from supply (resource extraction) to demand (energy services). The model can help design long term strategies by analyzing optimal energy mixes, investment needs and other costs for new infrastructure, energy supply security, energy resource utilization, rate of introduction of new technologies (technology learning), environmental constraints, etc. It can also help evaluate the impact of environmental regulations, in particular the carbon tax implications, on energy system development.

National teams conducted national studies using MESSAGE and developed long-term scenarios and during the final period of the project they organized national seminars to disseminate the information they had gained. These national studies have directly

supported or influenced the decision-making process for national or local long-term electricity planning in the RCA Member States and have provided policymakers with technically sound information to support meaningful participation in international dialogue and negotiations related to green house gas (GHG) abatement efforts (see the box on the climate change and energy issue).

Some of the notable examples of the project outcomes include: the long-term strategy paper for development of nuclear power in India; and, the study on an energy security initiative in Pakistan. The latter made the official goal for a nuclear power development set by Prime Minister of Pakistan.

At the regional level these RCA projects have fostered regional cooperation and facilitated integrated analysis of regional energy, economic and environmental issues.

As an important step, those Member States already using nuclear power as an energy option; China, India, Korea and Pakistan, are seriously considering adopting energy policies that have an increased dependency on nuclear power in their energy supply scheme. Indonesia and Vietnam have proposed the inclusion of the introduction of nuclear power in their prevailing energy plans,



while other Member States - Bangladesh, Malaysia, the Philippines and Thailand - are taking into account the potential introduction of nuclear power as an energy option. These moves emphasize the growing importance of the outcomes of these RCA energy projects in supporting national decision making in the participating Member States surrounding the introduction/expansion of nuclear power in the region.

Climate Change and the Energy Issue

As the largest emitter of carbon dioxide, the increasing use of fossil fuel will have a stake in the climate change with consequent impacts on land and agriculture, water resources, coastal zones, forest and biodiversity, etc. Increasing use of low-carbon/carbon-free energy resources and technologies, like renewable energy sources and nuclear power, is required to meet the increasing energy needs, while reducing the level of greenhouse gas emissions. Making decisions on energy technologies has important and direct implications on plans to mitigate climate change.



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Enhanced Energy Analysis and Planning Capabilities



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Improving Livestock Productivity while Conserving the Environment

Livestock farming is of the utmost importance to most developing countries as a source of food and of income for the rural population. However, the productivity of the livestock in most of the developing countries is much below its potential due to malnutrition, reproductive mismanagement, infectious diseases, and a lack of effective support services, such as Artificial Insemination (AI). Also improving current management practices has the potential to reduce the environmental effects of livestock farming by reducing the emissions of greenhouse gases that contribute to global warming, such as methane and carbon dioxide, as well as reducing the release of other by-products into the environment.

As a result of the RCA projects on animal production it has been possible for the RCA Member States to improve nutrition and develop reproduction strategies using nuclear and nuclear-related techniques. These strategies have made it possible to increase the weight gain and the milk production of farm animals while reducing methane emissions, and to achieve genetic improvement of the livestock. In developing nutrition strategies, isotopes of carbon, hydrogen, sulphur, phosphorous or nitrogen were used to study the conversion and uptake of feed nutrients, and to evaluate the role of microbes in digestion in the rumen of livestock. Ruminant animals like cows and goats rely on these microorganisms in their digestive tract to convert feed components into useable sources of energy and protein.

A formulation for feed supplementation, called Urea Molasses Multi-nutrient Blocks (UMMB), was developed from locally available feed resources using the knowledge gained through the application of above-mentioned techniques, under a regional project implemented from 1995 to 1999. Through a follow-up RCA project implemented from 1999 to 2004, these UMMBs were used to deliver the medication required to control internal parasites, thus ensuring better nutrition as well as improved health of the animals. Participants in this project also engaged in enhancing the efficient use of locally available feed resources by evaluating their nutritional value using stable isotope and radioisotope techniques and by developing improved feeding strategies. Medicated blocks and herbal remedies offered cost effective means of worm control in farm animals in almost all the participating Member States. Out of the 47 new feeds evaluated by participants in this project, 39 feeds had been identified as having a good potential to be used as animal feeds. The new feeds had been introduced to farmers in 5 Member States.

UMMB

The urea molasses multi nutrient blocks (UMMB) are lick-blocks containing urea, molasses, vitamins, minerals and other nutrients.UMMB is a convenient and inexpensive method of providing a range of nutrients required by both the rumen microbes and animals, which may be deficient in the main feed. This technology was developed through a research project and transferred to the Member States through a regional TC project.



Urea-Molasses Multinutrient Blocks



Cattle licking a UMM block which gives slow release of nutrients.

The second RCA Project was implemented from 2005 to 2008 and focused on conserving the environment by reducing emissions of green house gases (methane, carbon dioxide) and releases of certain nutrients (nitrogen and phosphorous) into the environment. The participants were trained on better feeding strategies, improved manure management practices and methane reduction methodologies. Various activities were carried out such as field trials on different feed supplements, rumen manipulation (e.g. with coconut oil, plant saponins, medicated UMMB, concentrates, herbal extracts, etc), and different practices of manure management. The project also produced guidelines on manure management for the use by the Member States.

These strategies resulted in increased milk production and weight gain in dairy animals. Increased milk yields by approximately 25% were observed in Bangladesh and the Philippines. Bangladesh, China, Indonesia and Myanmar reported increases ranging from 15 to 70% in the average daily weight gain of animals. The feeding strategies, like the use of medicated UMMBs and herbal remedies, enhanced income levels for farmers with the reported increase of income per animal ranging from 33% to 445%. In Bangladesh, China, Indonesia, Pakistan and Thailand, the reduction in methane emissions due to adoption of the new feeding strategies ranged from 15 to 70%. Bangladesh, Indonesia, Pakistan and Sri Lanka reported on improved manure management practices that increased the utilization of nitrogen and phosphorous in the manure for crop production, which resulted in increased yields of rice and fodder ranging from 25-40%. Most of the participating countries disseminated the knowledge gained for supplementary feeding and for efficient manure management to the end users. Selected farmers (lead farmers) were trained in the new feeding strategies.

The RCA Projects also focused on breeding and reproductive management of livestock. Artificial Insemination (AI), with diagnostic support in the form of radioimmunoassay (RIA) technology, was used to improve the reproductive efficiency of cattle. The isotope-based RIA technique enables the measurement of reproductive and other hormones in milk, serum or plasma, and this gives a better understanding of the reproductive status of livestock. It is an important tool for: determining when animals are ready for breeding; diagnosing non-pregnancy at an early stage so that animals can be re-bred; and diagnosing reproductive disorders in order to respond with appropriate treatment. These measures contribute to an overall improvement in the success rate of AI.

Through the RCA project implemented from 1999 to 2004, participants



The reproductive efficiency of cattle subjected to Artificial Insemination was improved with diagnostic support using radioimmunoassay (RIA) technology for measuring progesterone.

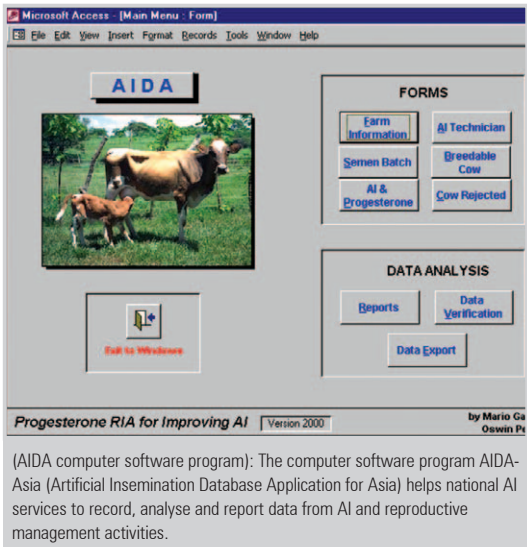
developed the capability of using RIA to measure progesterone for improving the AI services used by farmers. They also developed the capability of using two databases termed AIDA-Asia (Artificial Insemination Database Application for Asia) and SPeRM (Semen Processing Records Management), for data management by national AI services. These databases, which had been developed under an FAO/IAEA coordinated research project, were subsequently refined under the framework of this project for the use by national AI services in the region, for recording, analyzing and reporting data from AI and reproductive management activities.

As a result of this project, China, India, Malaysia, Mongolia, Myanmar, Pakistan, Sri Lanka, Thailand and Vietnam consolidated their ability to sustain the use of RIA by making the standards and quality control samples in national laboratories. The RCA Project implemented from 2005 to 2008 focused on identifying and adopting better breeding strategies that would improve animal productivity through: the use of better selection criteria for offspring from cross-breeding programs; the optimum utilization of appropriate indigenous cows; benchmarking for growth and reproduction; and, improving procedures for management, nutrition and healthcare programs in dairy farms. It provided regional training on selective breeding and potential applications of molecular genetic techniques, as well as guidelines on the selection of breeding heifers.

Almost all the participating Member States achieved genetic improvement in their livestock through different reproductive techniques. For example, India and Sri Lanka achieved this through the use of synchronization programmes, insemination with genetically superior semen and embryo transfer (ET); while Bangladesh used in-vitro fertilization (IVF) and ET programmes; and Myanmar, the Philippines, Indonesia and Thailand used cross-breeding programmes.



(Cross-bred buffaloes): A group of cross-bred buffaloes in Sri Lanka, produced through AI on indigenous cows using semen from improved Murrah bulls.



(AIDA computer software program): The computer software program AIDA-Asia (Artificial Insemination Database Application for Asia) helps national AI services to record, analyse and report data from AI and reproductive management activities.

reproductive techniques and nutritional supplementation to improve the production and the reproduction of local and cross-bred cattle and buffaloes. Most of the Member States have disseminated the knowledge gained to end-users, including farmers, extension workers and livestock professionals.

Most of the Member States designed and applied standardized criteria for selection of better breeding heifers, based on the recording of performance of their parents. In the Philippines, additional parameters like milk composition, were taken into consideration. Laboratory protocols for in-vitro maturation (IVM) and IVF of oocytes, semen preservation and cryobanking of gametes have been established by Bangladesh, Sri Lanka and Indonesia.

All the participating Member States have included improved



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**Improving Livestock Productivity while
Conserving the Environment**



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Combating Soil Erosion-Caused Land Degradation in the Asia and the Pacific Region

At the turn of the 20th century, the rapidly growing populations of most countries in the Asia and the Pacific region and the consequent need for greater food production, have imposed increased pressures on land and water resources leading to intensive land use/management over extensive tracts of land. All these changes, combined with burgeoning urban, industrial and transport infrastructures have resulted in widespread degradation of land and water quality through accelerated soil erosion and increased sedimentation, flooding and pollution of downstream water bodies. Furthermore, severe soil erosion and sedimentation problems have been worsened in the region due to improper land use and poor farming practices.

Soil erosion degrades soil, reduces land productivity, and hence adversely affects overall environmental sustainability. There is a direct contribution from these impacts to food insecurity and to increased malnutrition. The chain of consequences

does not end there because malnutrition often results in higher levels of poverty, which may then be a factor for rural migration and social unrest, all of which lead to poor economic development. Implementation of effective soil conservation practices has the potential to contribute substantially to mitigating these problems.



Deforestation and intensive cultivation on steep land led to severe soil erosion in the tropical uplands of Thailand



Collection of samples for the assessment of reservoir sedimentation rates in an arid environment in South East Australia using fallout radionuclide techniques

Measuring soil erosion is a key element in designing effective soil conservation strategies. Reliable quantitative data on the actual rates of soil erosion are required so that a more comprehensive assessment of the magnitude of its effects can be conducted. These data can be used for better understanding of the main factors involved in soil erosion/sedimentation and validating new soil erosion/sedimentation prediction models. In addition this information provides a basis for developing scientifically-sound land use policies and selecting effective soil conservation measures and land management strategies, including assessment of their economic and environmental impacts.

Soil erosion research is capital- and labour-intensive as well as time-consuming. Well-designed experiments using standardized methodologies have to be performed to ensure that the data obtained are comparable and representative of the study areas. Existing classical techniques such as erosion plots and surveying methods for monitoring soil erosion are capable of meeting some of these requirements but they have a number of crucial limitations in terms of the representativeness of the data obtained, their spatial resolution, and the potential to provide information on the long-term rates of soil erosion and associated spatial patterns over extended areas, as well as the costs involved. There has been a quest for alternative soil erosion assessment techniques to complement the existing methods and to meet new requirements that have arisen because of the introduction and application of distributed numerical models, the Geographical Information Systems (GIS) and geo-statistics. As a result, attention has been directed to the use of fallout radionuclide techniques and these have proved to be very effective in conducting such measurements.

The RCA Member States, recognizing the benefits of using these nuclear techniques to address soil erosion and related issues, decided to develop the required capabilities through two RCA projects implemented

under the IAEA Technical Cooperation programme. These RCA Projects were focused on developing sustainable land and water management strategies for reducing soil erosion and improving soil and water quality in the region. These projects used the latest nuclear-based techniques, namely fallout radionuclides (FRNs). Under the first regional project, implemented from 2001 to 2005, the national teams in participating RCA Member States gained the capacity to conduct soil erosion measurements using the caesium-137 (¹³⁷Cs) technique. Under the second regional project, implemented from 2005 to 2009, more advanced radioisotopic techniques involving the combined application of caesium-137 (¹³⁷Cs) with other radionuclides such as lead-210 (²¹⁰Pb) and beryllium-7 (⁷Be) were introduced. These techniques were used to investigate soil erosion/redistribution over a range of time scales (from less than one month to up to one hundred years), and to establish the relationship between soil redistribution and soil and water quality.

A major challenge for each participating Member State was the need to form a multi-disciplinary and often inter-institutional team of researchers with complementary skills and expertise in soil erosion research (soil science, soil geography, hydrology, land care/husbandry, agronomy, ecology, soil conservation, etc.) as well as nuclear sciences. In addition basic infrastructure/equipment to perform the required field and laboratory work had to be available. The IAEA assisted developing Member States, as required, in the establishment and strengthening of their human and institutional capacities as these were essential requirements for the successful and effective application of the FRN techniques in soil erosion studies. Laboratory quality control assurance and relevant expert services on the use of FRN techniques were provided for the participating Member States to improve their national capacities.



Learning together the principles of the Fallout Radionuclide techniques for measuring soil erosion and determining the effectiveness of soil conservation measures during the IAEA/RCA Regional Training Workshop in China (Beijing, 2005)



Collection of bulk core soil samples for fallout radionuclide analysis to assess soil erosion and sedimentation rates under different land uses in the Philippines

These RCA's regional projects have made an important scientific and technical contribution to the protection of land and water resources and environmental sustainability in the region. The national teams from the participating Member States have obtained a wealth of valuable information on soil erosion rates in agricultural landscapes and assessed the effectiveness of soil conservation measures through the use of nuclear and related techniques in a wide range of environments of the region.

The techniques are now becoming recognized as essentials tools in land care/management programs, and the number of organizations adopting this nuclear technology continues to grow through the implementation of land development projects. Specifically, FRN capacities of a high technical level have been established in China. As an example, effective soil conservation measures identified by this regional project at Yan'an site (80,000 ha) in the Loess Plateau, China, have substantially reduced soil erosion and project data were used by the Ministry of Soil and Water Resources, China, to establish water quality maps.

Based on the results of this assessment, recommendations were made to the land management practitioners on how to improve their soil conservation policies as well as how to restore land productivity across the region.

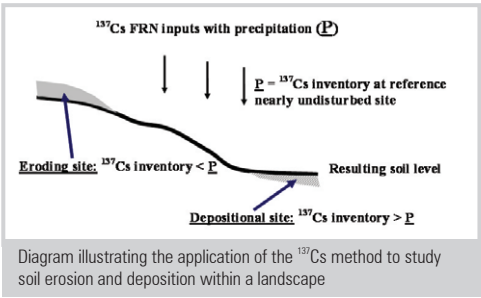


Combination of soil conservation measures at Yan'an site in the Loess Plateau, China

**Nuclear technology:
Fallout Radionuclides (FRNs) as tracers in soil erosion studies**

In soil erosion and sedimentation investigations, work has been focused on the use of a particular group of environmental radionuclides, namely fallout radionuclides, which include caesium-137 (¹³⁷Cs), excess lead-210 (²¹⁰Pb_{ex}), and beryllium-7 (⁷Be). These radionuclide techniques, in combination with classical methods, are very effective tools to complement and meet new methodological requirements in the assessment of soil erosion and the evaluation of the efficiency of soil conservation practices.

The basic principles for the application of these FRNs in soil erosion and sedimentation studies are similar. The fallout input of these natural (⁷Be and ²¹⁰Pb) and artificial (¹³⁷Cs) radionuclides from the atmosphere to the land surface occurs through wet (rainfall) and dry (wind) deposition. It is assumed to be spatially uniform, at least over a relatively small area. Once these radionuclides are deposited, they are rapidly and strongly adsorbed by fine soil particles (clay and humus) and accumulate at or near the soil surface. Documenting the subsequent redistribution of the FRN tracers, as they move across the landscape in association with soil or sediment particles, primarily through physical processes, affords a very effective tool for measuring erosion and deposition by water, wind and tillage within agricultural landscapes. The resultant soil redistribution data (soil and sedimentation rates and patterns) represent an integrated measurement of all effects leading to soil redistribution and occurring during the period extending from the time of the main input from the atmosphere to the time of sampling. When using several radionuclides, soil redistribution data over different time scales (from less than one month with ⁷Be to up to fifty and one hundred years with ¹³⁷Cs and ²¹⁰Pb_{ex} respectively) can be obtained using a single sampling campaign, thereby avoiding the time-consuming and costly installations and procedures commonly required by the non-nuclear methods to monitor study sites over extended periods of time.



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RCA Innovation Supporting Regional Chemical, Petrochemical and Petroleum Industries

Major industries and particularly those involved in the operation of chemical, petrochemical and petroleum plants, have long recognised and used radiotracers and sealed source technologies as effective tools for online control and measurement as well as indispensable agents for troubleshooting when problems occur. The cost effectiveness and the suitability of nuclear technologies for exploitation in industry led to the establishment of “in house” teams to apply the technologies and at the same time this move to keep the skills “in house” also protected the industries’ commercial advantages and operational secrets. A consequence of this restricted availability of the technology has been that often emerging industries in the RCA Member States have had limited or no access to many of these technologies and have not been able to benefit from the associated efficiencies and cost savings.

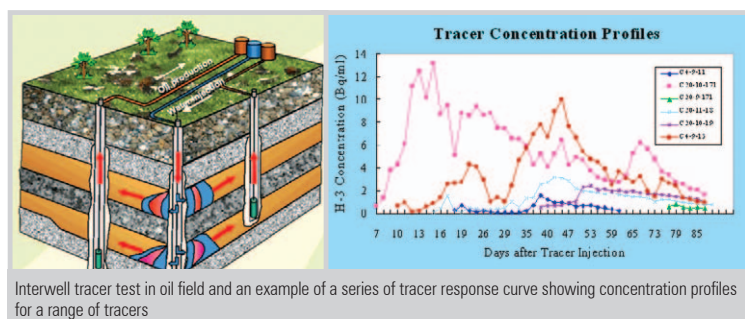
In response to this situation a series of RCA projects on radiotracers and sealed source technology have been implemented to transfer this knowledge and enhance the capabilities and capacities of RCA Member States to respond to the needs of regional industries. Member States have established local teams to acquire the knowledge and skills being transferred. These teams carry out the important task of interacting with local industries to inform them of the new range of techniques available to assist them in their operations and, where suitable, they carry out demonstrations or longer term studies. In addition, this contact with industry enables the teams to learn more

about the needs and problems in this sector and hence they become better able to identify where nuclear techniques can assist.

Many teams have not been content just to receive the transferred technologies through the projects. They have carried out additional adaptation and development of the technologies to meet the special needs of particular industries in their country as well as providing services to relevant industries on a regular basis. The following two examples are in selected areas of significant importance to the chemical, petrochemical and petroleum industries and illustrate the achievements and skills of these local teams as they build on the knowledge transferred through the RCA projects.

Radiotracers for Interwell Studies in Oil Fields

The Fundamentals: the extraction of crude oil from underground sources is mostly a difficult and expensive undertaking. Crude oil is found in various rock strata and usually water and gas are also present. Natural underground pressure formed when this mixture expands, can force it to the surface in a process that is usually termed *natural production or primary production*. However this is not a very efficient process and only about 25% of the original oil in place will be extracted, with the remaining 75% being held in pores and fissures of the various strata.



A further 50% of the original oil in place can be recovered through a process called *secondary recovery*, in which water is injected below ground through special wells (injection wells) to help flush out the remaining crude oil, which is extracted from a series of other wells (production wells) surrounding the injection well. The efficiency of the water flooding process is highly dependent on the nature of the rock strata, the characteristics of the fluid being extracted as well as the water injection strategy. Optimum recovery of the oil can be achieved if all these various factors are known and this is where the power of the tracer technology is revealed.

The underground flow behaviour of the fluids between the injection well and the production well(s) can be measured by adding a tracer to the injection water. Periodic sampling at the production well(s) and analysis for the tracer will provide what is termed a *tracer response curve*. Specialist analysis of this curve can then provide the important information about the character of reservoir and makes it possible to optimize the injection regime, improve the production strategy and thus maximize the overall recovery of the crude oil.

Member States’ Innovations in Interwell Tracer Technology (IWTT): in China, the Project Team at the China Institute of Atomic Energy (CIAE) has been engaged in interwell tracer test in industry, has established an interwell radiotracer laboratory and promoted its application in China. The team has developed new tracers, tracer analysis techniques and computer modeling and simulation techniques. At present the Project Team conducts 400 well operations annually in the oilfields. In addition work has been carried out in other countries; for example contract work has been undertaken in Kazakhstan and proposals for reservoir tracer tests have passed technical evaluation in Oman and Libya.

In Vietnam, the Centre for Applications of Nuclear Technique in Industry (CANTI) have established an interwell radiotracer laboratory and have developed improved tracer methods for high temperature and fractured basement reservoir conditions. They have established their capability for the investigation of oil reservoirs in Vietnam oil fields and are now providing routine commercial service to most oil fields in Vietnam. The Vietnam tracer group has won an international bid for interwell tracer tests to be performed in local oil fields and earned more than US\$2 million. CANTI has been developed as an independent and self-reliant centre.



Tracer injection in oil field by the Chinese team



Tracer injection preparations by CANTI at an offshore oil field



Sealed Gamma Sources for Scanning Distillation Columns

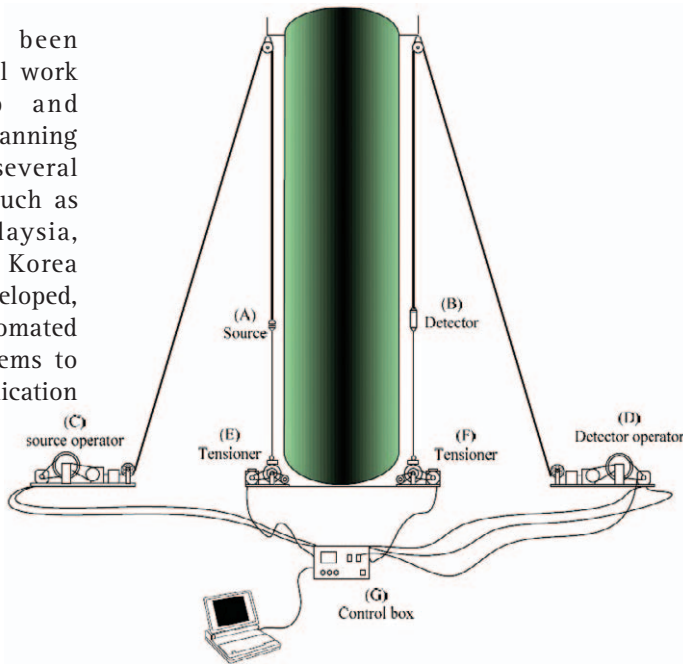
The Fundamentals: distillation columns are essential and critical components in the operation of chemical, petrochemical and petroleum plants. If these units begin to show evidence that they are not working to specification or some malfunction is suspected, then diagnostic procedures have to be brought in rapidly so that the required remedial actions can be carried out promptly.

Gamma radiation has great penetrating power and can pass through significant thickness of steel and other metals and construction materials. Detection of the changes in intensity of gamma radiation as it passes through a distillation column provides a picture of the internal structures and arrangements inside the column and most importantly can be undertaken while the column is operating. This basic principle has been the basis for the technique behind the scanning of industrial distillation columns, which over many years has been demonstrated to achieve reliable identification and the localization of faults or malfunctioning. Follow up actions by the plant organization, with timely repairs and consequent restoration of normal functioning of the column, returns the operations to the desired state and a timely diagnosis results in significant cost savings.

Unlike the IWTT, where the tracer materials are introduced into the injection fluid, the radioactive materials used in column scanning are sealed in capsules and cannot make physical contact with either the plant or the materials being processed. Only their gamma radiation is utilized. Often, this radioisotope application is the *only* way by which the necessary information about the distillation column performance could be obtained.

Member States' Innovations in Column Scanning

Project teams have been carrying out additional work to further develop and improve the column scanning operation. Teams in several RCA Member States, such as India, Indonesia, Malaysia, Pakistan, Republic of Korea and Thailand, have developed, or are developing, automated column scanning systems to further commercial application of this technique.



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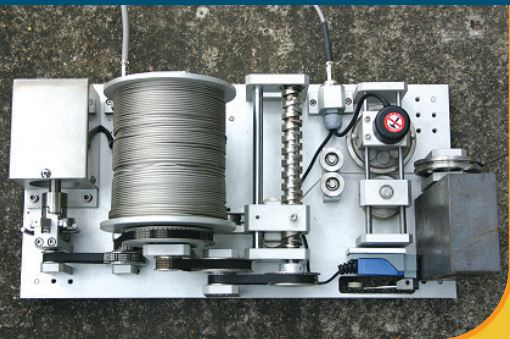


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