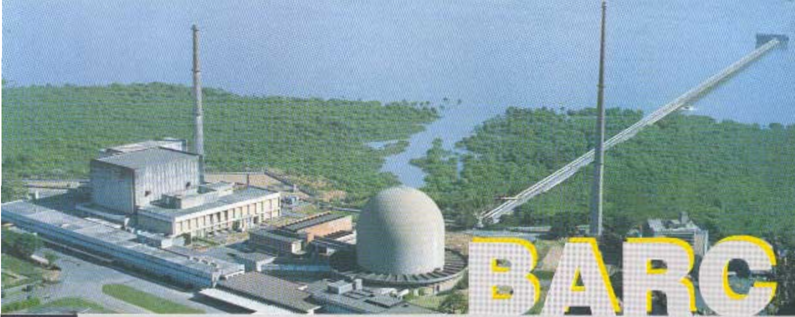


No. 191,
December
1999

BARC NEWSLETTER

From the Director ....

Dear Colleagues,

New Year Greetings.

As we enter the thresholds of new millennium, we are witnessing major and rapid transformations in a variety of things around us that affect our lives. These transformations have posed many challenges. They also offer a large number of opportunities. It is upto us to maximise the benefits to our country and to our society by conducting ourselves in the most effective manner in this fast changing world. One cannot remain static and be a silent spectator considering the realities of the new inter-dependent world order.

Contents

Technologies and the mind set that allow maximisation of domestic value addition in all activities around us with export far exceeding imports are in my view the key to our relative success. To succeed, we must be innovative in making best use of our human resources as well as the mineral and agricultural wealth.

I have always described BARC as a technological gold mine. Our main mandate is to open up the vast energy potential in our uranium and thorium resources and cater to our large energy needs. While this is our primary mandate, we also have the opportunity to provide technological solutions to other essential needs such as water, food, health and wealth generation. We also know that we can provide these solutions in a sustainable and environmentally benign manner. We have a clearly defined programme ahead of us. During the last few years, we have made conscious efforts to define a large number of Task Forces for specific programmes with a view to broad base participation of our scientists and engineers and pool together our multi-disciplinary strengths.

The rapid transformations that are taking place necessitate that we evolve our solutions and put them in place in the shortest possible time. Achieving this through our innovations automatically gives us a degree of advantage relative to others. In the long run, this opens up the possibilities of our emerging as global technology leaders in the particular area. At BARC, we are in a particularly advantageous position in this regard and I would like to suggest that all of us make a resolve to take up this challenge.

My best wishes to you all.

Anil Kakodkar

MICROPROCESSOR-BASED TRACTION CONTROL SYSTEM FOR 25 kV AC LOCOMOTIVES

Y.S.Mayya, Vinod Deodhar, Vivek Sanadhya, U. Mahapatra, M.K.Singh and G.P.Srivastava
Control Instrumentation Division

Genesis of the Project

Indian Railways have a large variety of AC locomotives in their fleet. The propulsion system adopted in these locomotives is through DC drive. In these locomotives, the AC voltage tapped from catenary (22.5 kV) is stepped down and converted to DC, using silicon rectifiers. Tractive effort control is achieved by on-load tap changers mounted on the transformer.

It is well known that voltage control using mechanical tap changer is not step-less, resulting in poor realisable adhesion. The tap changer also poses maintenance problems. There are very few suppliers for this component and its supply has always been short of demand.

To obviate the above problems, thyristorization of locomotive drive system was taken up during the 1970s, which incorporated analog controls and relay-based interlocks. BARC has pioneered this technology in India. With the aid of a few industrial units, thyristor converter was developed for replacing tap changers in a few of the existing WAG1, WAM1, WAM2 and WAM4 locomotives.

Meanwhile, microprocessors were being introduced for the control of locomotives around the world. The traction control technology of the 1980's was based on general purpose 16 bit microprocessors with software-based control. 1990's saw the proliferation of 16 bit micro controllers with built-in features targeted for converter/ inverter control applications.

Generally, computer - based control offers many well known advantages such as, increased flexibility in implementation, insensitivity to ageing and drift. More significantly, it facilitates integration of fault diagnostics, guidance, logging and monitoring functions with the traction control system, resulting in increased reliability and availability. Software-based loco interlock can do away with a large number of TDRs, relays, by-pass switches and associated wiring. Interconnection of multiple locomotives can leverage the serial data communication technology, using, for example, a couple of twisted pair wires as against around 57 wires required otherwise for multiple loco operation.

In 1992, the Research Design & Standards Organisation (RDSO) of Indian Railways approached the Railway Board with a proposal for indigenous development of microprocessor-based traction control systems, primarily targeted towards retrofitting the large fleet of tap-changer locomotives owned by Indian Railways. BARC was identified as a partner in this development and DOE agreed to part-finance this work.

The development and manufacture of hardware and software for the traction control system was taken up at BARC. A bench test facility was set up at RDSO to help in initial testing and validation. ECIL was made responsible for manufacturing the converters as per BARC and RDSO's design.
A WAG5 series locomotive (Loco number, 23026) was nominated for retrofitment. The locomotive was

modified at Electric Loco Works (ELW) at Bhusawal and was retrofitted with the converters and controller cubicles. The testing and commissioning was started during late 1996 and was carried out in phases during many sessions throughout 1997. During March 1998, full-load line trials were conducted quite satisfactorily and all the major technical objectives of the project were realised.

Plate 1. The electric locomotive, retrofitted with thyristor control system at ELW, Bhusawal

System Functions

The Traction Control System is deployed on a modified WAG5 series locomotive which is propelled by six numbers of ~700 HP, separately excited DC traction motors, arranged in two groups of 3 motors each. Each of the motor armature is powered by a thyristor converter, which is made up of two half-bridges connected in series. The DC armature voltage is varied by changing the firing angle to the thyristors. This is done in two-steps : in the 0 to 50% voltage range, the upper of the two half bridges is phase angle controlled and the lower half-bridge is OFF; in the 50% to 100% range, the upper bridge is fully conducting whereas the firing angle for the lower bridge is varied. This two-step sequence control improves linearity of the converter. [Figures 1, 2 and 3]

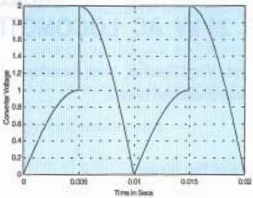


Fig. 1 Two step sequence control: Upper half bridge is fully conducting and lower half bridge is at 50% conduction

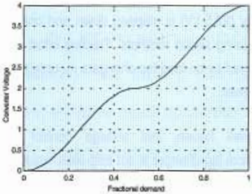


Fig. 2 Normalised converter DC voltage vs demand (no overlap)

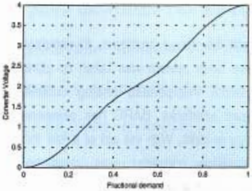


Fig. 3 Overlap (10%) provides better converter

The voltage (and hence current) of each of the armature converters is independently variable. But the field windings of all three motors of a group are connected in series and powered by a single field converter. This arrangement allows current sharing among motors by accommodating variations in motor characteristics and wheel diameters. A reverser in the field circuit is used to reverse the direction of field current and hence, that of the loco. During rheostatic braking, the armature converters are isolated from motors and dynamic brake resistors are connected across the armatures. The armature and field currents (Ia,If) and the armature voltages (Va) are sensed by hall-effect sensors and are used for monitoring and closed loop control. The axle speeds are sensed by pulse tachos and used for slip/ slide detection.

The traction control system performs the following functions:

- Independent phase angle control for all thyristors with limits on the minimum and maximum firing angle. Two step sequence control of the armature converter with overlapped control around 50% voltage point.
- Closed loop control of the armature and field currents. Generation of reference (demand current) based on master controller operations, in traction and braking regions (notching-up/ notching-down). Weight transfer compensation. Automatic sequencing and control in three traction regimes : i.e. constant torque regime, constant HP regime and constant Ia/ If regime, as the loco accelerates from stand-still to balance speed.
- Braking effort control during rheostatic braking. etection and reduction of wheel slip during traction and wheel slide during braking. Implementation of operational and safety interlocks of the locomotive and control of various loco equipment such as panto, main circuit braker, blowers, etc.
- Detection of faults in the locomotive, power circuits and controller electronics, annunciation of faults and logging of faults. Support for viewing and clearing faults and for conditional bypassing of faulty equipment.
- Single bogie operation capability.
- Provision for multiple loco operation.

Traction Control System Architecture

In order to realise the above functions, the traction control system deploys multiple microprocessors and micro-controllers. It has a distributed and layered architecture consisting of the following five nodes which are interconnected using a master /slave network, i.e. CARNET.

- Traction Control Computer-1 (TCC-1)
- Traction Control Computer-2 (TCC-2)
- Cab Interface Unit-1 (CIU-1)
- Cab Interface Unit-2 (CIU-2)
- Fault Log Unit (FLU)

The following system requirements have guided the evolution of the above system architecture:

- *Redundancy considerations:* Since the locomotive can be hauled using any one of the motor groups, there should be redundancy in the controllers too, so that single bogie operation is feasible. *Operational requirements*: Loco can be driven from master controller located in either of the cabs. The BL key identifies the currently active cab.
- *Integrated fault logging* : All faults in the loco must be logged in a unified way.
- *Cabling considerations*: Fairly large number of control and monitoring devices are located in the cabs which are required to be interfaced to the controllers.

Traction Control Computers (TCC-1 & TCC-2)

A locomotive comprises of two bogies, each with its individual set of three motors, converters and master controller. Additionally, there are some equipment which are bogie specific and others which are common to the loco as a whole. Single bogie operation envisages a scenario wherein driver should be able to move the loco even when there are faults in one of the bogies (motors, converters, etc.). This requires redundancy in traction controller hardware. Hence, there are two Traction Control Computers - one for each bogie. TCC-1 controls motors of group-1 and TCC-2 of group-2 (Fig. 4). While the bogie specific devices are interfaced to the corresponding TCC, the loco common devices are connected to both the TCCs. However, such common equipment should be actuated by only one TCC at a time (master), with the control switching over to the standby TCC in case of failure of the current master. The two TCCs continuously monitor the health of each other and a distributed arbitration logic grants master-ship to one of the TCCs. The common equipment are under the control of the master TCC.

Each TCC is controlled by a 80286 processor which hosts all loco logics and supervisory control functions [Fig. 5]. A motor controller card with two numbers of 80C196KC - 16 bit microcontrollers is used to generate phase angle controlled thyristor trigger pulses for all 4 converters (3 for armature and 1 for field) of one bogie. It also implements four current control loops - three motor armature current controllers and the common field current controller. The three processors (80286 and the two 80196) execute in close co-operation, periodically exchanging parameters with each other using a 3-way bi-directional FIFO interface. [Fig. 6]

Each TCC also has many binary IO cards for interfacing 110V level loco devices to the system.

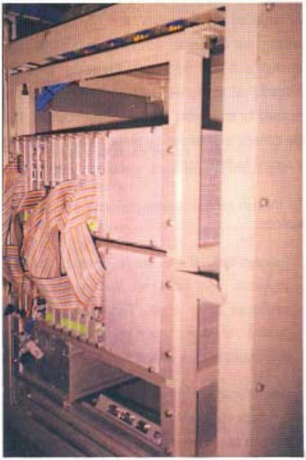


Plate 2. Traction control computer fitted inside the locomotive

CAB Interface Units

Each of the two cabs contains control and indicating devices which provide the driver's primary interface to the locomotive. This includes master controller, BL key, current/ voltage meters, fault display and key-pad, etc. Normally, these devices would be interfaced to the TCCs using discrete wiring. A better alternative is to locate interface electronics at the cab itself and extend these signals to the two TCCs via serial communication links. In addition to reduction in cabling, this approach also reduces interface hardware at the TCCs.

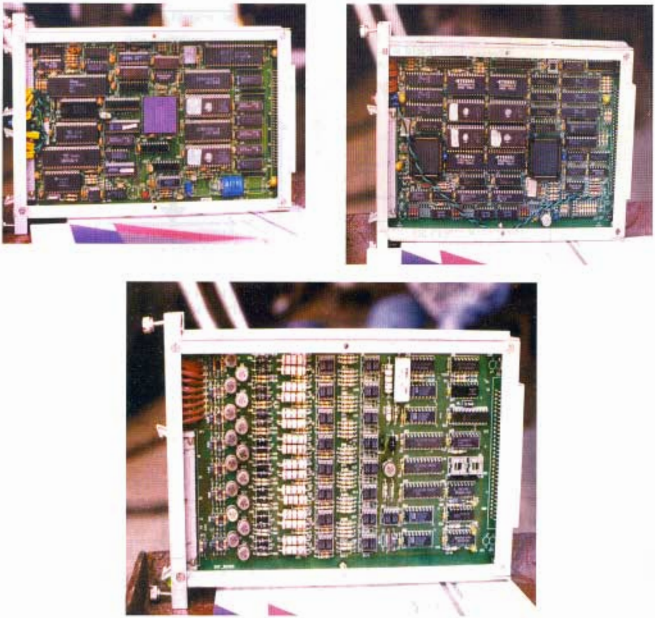


Plate 3. Controller cards

Hence, a 8044 microcontroller based Cab Interface Unit (CIU) is located near each of the cabs (Fig. 4). This unit contains isolated binary input channels (110V), analog output channels (meters), RS232C serial port (VFD) and a few binary output channels (lamps). CIU is a CARNET slave and communicates with the TCCs through CARNET.

Fault Logging and Display

The traction control system integrates a Fault Log Unit (FLU) which provides services for non-volatile storage, display and retrieval of on-line faults occurring in the locomotive (Fig. 7). This includes faults in the power circuits, loco equipment and the traction control computers. Faults are detected by the Traction Control Computers as per pre-programmed fault logics. There are two kinds of fault storage:

Fault history : FLU will manage the storage of around 100 most recent faults in non-volatile memory as and when they occur in chronological order.

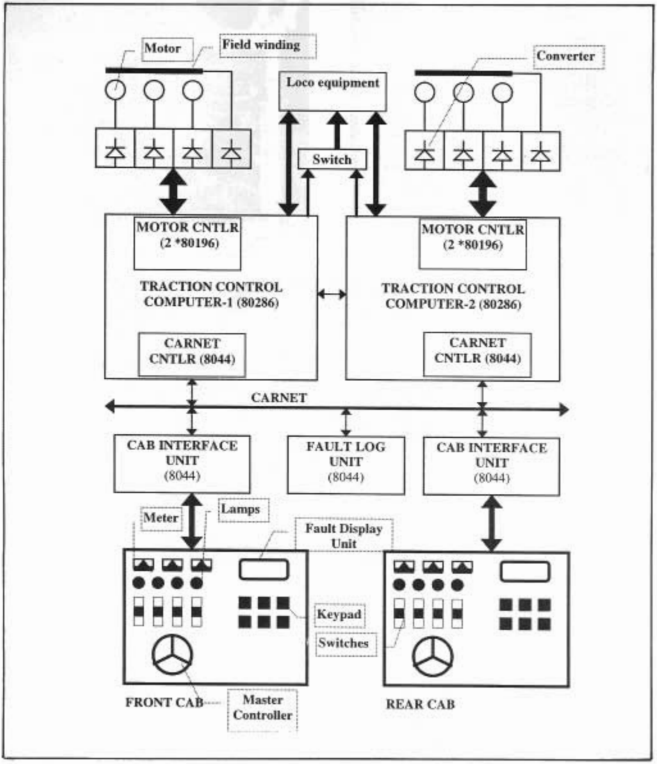


Fig. 4 Traction control system architecture

Fault status : FLU will facilitate display of remnant faults in the system. Fault status are grouped under eight functional categories for the purpose of viewing. The driver can make attempts to clear by-pass certain faults. A facility for isolating faulty equipment is also provided.

The faults are physically stored in non-volatile RAM of fault log card which is located in one of the TCC cubicles and interfaces to both the TCC and CIUs through CARNET. The faults detected by the TCC are sent to FLU as messages. Faults are displayed on each of the driver's cab on a 6 line by 40 character VFD based alpha numeric terminal (FLD). A set of 6 push-button switches are used by the driver to display, clear and by-pass faults. Each cab has one set of switches and FDU and the driver can access the FLU from either of the cabs. FDU and switches are physically wired to the cab resident CIU which exchanges messages with FLU through CARNET.

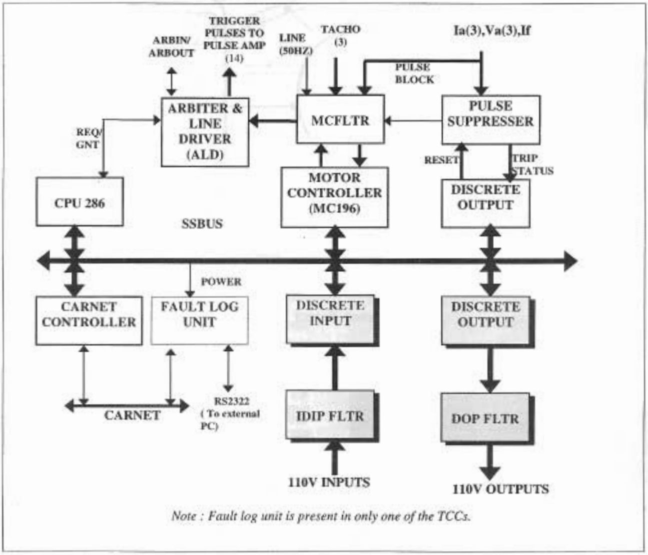


Fig. 5 Hardware block schematic of Traction Control Computer

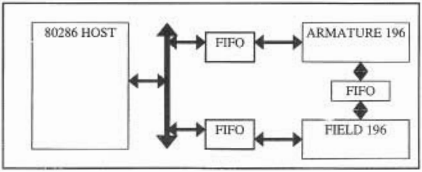


Fig. 6 FIFO based inter-processor communication

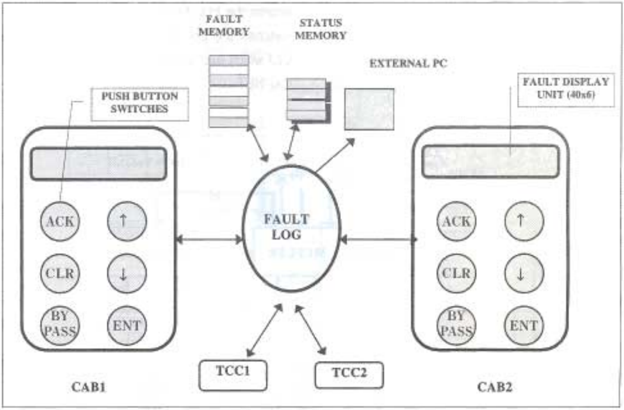


Fig. 7 Context diagram of fault log unit

Plate 4. Driver's cab showing master Controller

CARNET

CARNET is the communication back-bone within the loco and facilitates geographical distribution of control elements. It integrates the five nodes already mentioned. The communication requirements among these units is shown in Fig. 8. It is seen that there is a peer-to-peer message traffic.

CARNET is a SDLC protocol based Master /Slave network on twisted pair cable using RS485 signalling at 375 KBPS. Each of the five nodes of CARNET has a unique address. Either of the TCC nodes can become CARNET master; master-ship always rests with the active TCC. Message exchange takes place using command/ response transactions.

CARNET itself has a three layer architecture comprising of physical layer, link layer and message layer. The message layer is responsible for routing messages and application level protocols. The link layer is implemented by the 8044 communication micro-controller. The message layer is implemented by software and supports the exchange of application level messages.

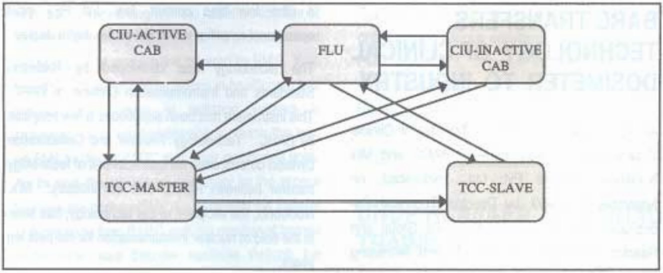


Fig. 8 CARNET message flow diagram

Block Control Language & Application Programming

The loco logics and control loops are programmed using function block based graphical language called Block Control Language (BCL). This tool was developed in-house and is generic enough to be useful in other projects as well. BCL allowed the technological solutions to be directly programmed in to the computer and enabled domain experts to develop and verify loco logics. It facilitated gradual, incremental addition and validation of logic and loops.

BCL has the following salient features:

- It allows control schema to be built using binary and analog variables freely.
- It is independent of processor and run-time environments (e.g., RT kernels).
- BCL code has deterministic execution model, e.g., single sequential task.
- It is extensible and customisable.
- All development is done on PC platforms.
- It leverages commercial schematic editors provided by electrical CAD software for drawing schematics.
- It generates 'C' source code and uses commercial C compilers.
- It supports partitioning among multiple computers and is extensible for distributed control applications.
- It has a large library of pre-built function blocks.

The function block library consists of scores of commonly used functions encompassing combinational and sequential logic functions (gates, multiplexers, registers), arithmetic functions (adders, comparators, limiters), controllers (PI), etc.

Conclusions

Microprocessor-based traction control technology is one of the more complex and challenging applications of computers in real-time control. With the successful implementation and validation of this indigenously developed technology, it is now ready for retrofitting in the 25kV AC locomotives of Indian Railways, on a trial basis.

BARC TRANSFERS TECHNOLOGY OF CLINICAL DOSIMETER TO INDUSTRY

An agreement for Technology Transfer of Clinical Dosimeter was signed between BARC and M/s Nucleonix Systems Pvt. Ltd., Hyderabad, on November 17, 1999, by Director, Technical Co-ordination and International Relations Group and Reactor Projects Group, BARC, and Managing Director of M/s Nucleonix.

Mr A.K. Anand, Director, Technical Co-ordination and International Relations Group and Reactor Projects Group, and Managing Director, M/s Nucleonix, sign the agreement for technology transfer of Clinical Dosimeter.

Clinical Dosimeter type RD-4B is a compact, battery operated instrument. It is designed to measure exposure rates due to gamma radiation upto 250 R/h. It is used for measurement of exposure rates in the bladder and rectum of patients undergoing treatment with Caesium or Cobalt implants for carcinoma of uterine cervix. The unit can also be used for exposure rate measurement in other body cavities.

The instrument consists of a miniature ionization chamber coupled to a stable D.C. amplifier by a 2-1/2 meter long triaxial cable. The D.C. amplifier is a ultra low bias current, low drift FET input operational amplifier which drives the digital display.

The technology was developed by Radiation Standards and Instrumentation Division of BARC. This instrument has been supplied to a few hospitals by BARC. Technology Transfer and Collaboration Division co-ordinated various activities of technology transfer between RS&ID and the industry. M/s. Nucleonix, the recipient of the technology, has been in the field of nuclear instrumentation for the past ten years.

RADIATION MONITORING BY PRIVATE SECTOR INITIATED

BARC accredited M/s Renentech Laboratories Pvt Ltd., Mumbai, the first laboratory in private sector, to provide Personnel Monitoring Service (PMS) to radiation workers in India. This laboratory has met all the stringent requirements of equipment, staff and training, and has undergone thorough evaluation of the scientific and technical handling capabilities and proficiency test by BARC as per procedures set by Atomic Energy Regulatory Board (AERB) - the apex regulatory body in India.

Since 1952, BARC has been providing centralised PMS to radiation workers in India, initially using film badges and later, since 1975, with indigenously developed Thermoluminescence Dosimetry (TLD) system.

By regulations, radiation workers are to be covered by individual monitoring. For this, a personnel monitoring badge, capable of recording the quantity of radiation encountered, is worn on the body (usually on the clothings at the chest level) of an individual while working with the radiation sources or radiation generating equipments. At present, about 40,000 radiation workers are covered by PMS. With the spread in the use of radiations in health care and industry, the number of radiation workers is increasing. This will considerably increase the load on PMS facility of BARC and other monitoring units. As, by now, the equipment necessary for the service has become commercially available with the transfer of technology from BARC and the number of trained professional have become available through the training provided by the department, personnel monitoring by agencies other than BARC have become feasible. It was, therefore, decided to accredit laboratories having sufficient infracture and expertise.

A document titled, *Accreditation Requisite Booklet (ARB)* describing the objectives, procedures, technical details and financial implications was prepared and, in 1998, an announcement about the intention of granting accreditation was made through advertisements in all leading newspapers in India. Amongst the applicants, M/s Renentech Laboratories Pvt. Ltd., was found the most promising and a PMS facility was set up as per the guidelines of ARB. After series of tests and evaluations, accreditation was granted on October 7, 1999, following which PMS agreement was signed on November 17, 1999. This laboratory will handle the load of 60,000 services/year equivalent to monitoring ~ 12,000 radiation workers a year. This laboratory will strictly operate under the supervision of BARC for QC&QA. With experience of this exercise, the accreditation will be considered for other laboratories in India in future.

This venture will try to meet the increase in demand of monitoring service in the country. Technology Transfer & Collaboration Division (TT&CD) co-ordinated the various activities of accreditation and PMS agreement, between industry and various divisions of BARC such as RPAD, RSSD, PMS of HS and E Group.

UNDP/RCA/IAEA REGIONAL TRAINING COURSE

A UNDP/RCA/IAEA Regional Training course on Radiotracer and Sealed Source Applications in Petroleum Industry was conducted by Isotope Group during September 20 - October 1, 1999 at Hotel Days Inn, Vashi. Eighteen overseas participants, one IAEA fellow from Algeria and 5 Indian participants attended the course. The local participants were from Engineers India Ltd., Indian Oil Corporation Ltd., Oil and Natural Gas Corporation Ltd., and Bhabha Atomic Research Centre.

Dr Anil Kakodkar, Director, BARC, inaugurating the UNDP/RCA/IAEA Regional Training Course.

The course was inaugurated by Dr Anil Kakodkar, Director, BARC, on September 20, 1999. Mr A.K. Anand, Director, Technical Co-ordination and International Relations Group, BARC, and

Dr S.M. Rao, Associate Director, Isotope Group, BARC, also spoke during the inauguration. Course Director, Mr Gursharan Singh, of Isotope Applications Division, proposed the vote of thanks. Mr Phillipe Berne from France was IAEA expert for this programme. Dr Jovan Thereska, Technical Officer, IAEA, was present for the concluding session of the course. The course dealt with various topics on radiotracer and sealed source applications in petroleum industry. Faculty for the course was drawn from ONGC, UDCT Mumbai and BARC. Use of French software for validating radiotracer experiment data was demonstrated by the expert. Radiotracer experiments along with mathematical modeling of the data were demonstrated during the course. Gamma scanning of a distillation column was demonstrated at M/s. National Organic Chemical Industry Ltd. (NOCIL), Thane.

The programme concluded on October 01, 1999 with the distribution of certificates to the participants.

IAEA-RCA TRAINING WORKSHOP

An IAEA-RCA Training Workshop on ICRP Recommendations & IAEA Standards was organised by Radiological Physics & Advisory Division at BARC, Mumbai, during November 1-5, 1999. There were in all 24 participants – 12 from ten South-east Asian countries, viz., Bangladesh, Indonesia, Korea, Malaysia, Myanmar, Philippines, Singapore, Sri Lanka, Thailand and Vietnam, and twelve Indian participants, including seven observers. The programme consisted of lectures, country presentations, discussions, work sessions and visits to BARC facilities. There were, in addition, two guest lectures – one by Dr V. Venkat Raj, Director, Health, Safety & Environment Group, BARC, on "Nuclear Reactor Safety", and the other by Dr S. Gangadharan, Chief Executive, Board of Radiation & Isotope Technology (BRIT), on "Isotope & Radiation for Health Care & Prosperity." The faculty members consisted of thirteen scientists from BARC, one from Atomic Energy Regulatory Board, and three IAEA nominees : Dr A.D. Wrixon, IAEA, Dr J. Valentin, ICRP, and Dr. J. Cooper, NRPB, UK. Dr K.C. Pillai, ex-Head, Health Physics Division, BARC, also served on the faculty.

Inauguration of IAEA-RCA Training Workshop (left to right) Dr B.K.S. Murthy, Dr V. Venkat Raj, Dr A. Kakodkar, Dr A.D. Wrixon and Mr A.K. Anand

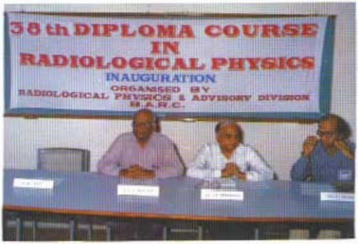
The lecture topics covered diverse fields such as Radiobiology, Transport, Public and Occupational Exposures, Safety and Security of Radiation Sources and Radioactive Materials, Medical Management of Radiation Injuries, Emergency Planning & Preparedness, Exemptions & Clearance, Protection of Environment, etc. Work sessions covered key topics such as Waste Disposal, Medical Exposures, Accident Management, Safety & Security of Sources, Public Exposures and Special Exposures. Four ICRP Publications (Publications 60,65,75,76) and four IAEA documents (IAEA-BSS 115, Safety Series 111-G-1, 111-F and Tecdoc 1067) were provided by IAEA for all the participants.

A compilation of lecture notes of all topics covered in the training course was also provided to all participants.

The Course was inaugurated by Dr Anil Kakodkar, Director, BARC. This was followed by a keynote address by Dr A.D. Wrixon, IAEA, on "Regulatory Infrastructure for Radiation Safety". In his inaugural address, Dr Kakodkar stressed the importance of radiation safety and outlined the radiation safety programmes of Department of Atomic Energy, India. At the end of the training course, there was a feedback session wherein the participants expressed their impressions and suggestions. The Training workshop concluded with a valedictory function and Mr G.R. Srinivasan, Executive Director & Chairman, SARCOP, AERB, delivered the valedictory address and distributed certificates to the participants.

38TH DIPLOMA COURSE IN RADIOLOGICAL PHYSICS

Radiological Physics & Advisory Division, BARC, conducts a one year post-M.Sc. Diploma course in Radiological Physics every year. This Diploma is awarded by the University of Mumbai. The Radiation Protection Rules 1971 stipulate that every radiation installation shall appoint a Radiological Safety Officer (RSO) with prescribed qualifications. This course provides the trained manpower for this purpose. Thirtyseven such courses have been conducted and 557 persons have been trained so far. The thirty-eighth course was inaugurated on October 7, 1999 by Mr G.R. Srinivasan, Executive Director, OPSD & Chairman, SARCOP, AERB, at CT & CRS building, Anushaktinagar.



Inauguration of 38th Dip. R.P. course by Mr G.R. Srinivasan, Executive Director, OPSD, AERB (centre). Others in the picture are Dr V. Venkat Raj, Director, Health, Safety & Environment Group (left), and Mr D.P. Bhatia, Head, RD&TS (right).

During the inaugural function, the first and second rank holders, Ms Aruna Kaushik and Mr Rajesh Kumar, respectively, of the 36th batch (1997-98) were presented the awards instituted by Atomic Energy Regulatory Board (AERB) for meritorious performance in the course. This year seventeen students from different parts of the country including three students sponsored by different radiotherapy centres had been admitted to the course. One of the sponsored candidates was from B.P. Koirala Memorial Cancer Hospital, Kathmandu, Nepal.

NUCLEAR GRADE TBP DEVELOPED

Solvent Development Section (SDS) of Uranium Extraction Division, Materials Group, has developed the technology for the synthesis of nuclear grade Tri-n-butyl phosphate (TBP), a vital solvent commonly used in nuclear chemical processing of Uranium and Plutonium. The technology transfer document was handed over on November 11, 1999, by Dr Anil Kakodkar, Director, BARC to Mr H.S. Kamath, Chief Executive, HWB, in presence

Dr C.K. Gupta, Director, Materials Group, BARC, formally handing over the technology transfer document of TBP synthesis to Dr Anil Kakodkar, Director, BARC. Mr U.R. Marwah, Head, Solvent Development Section, looks on.

of Dr C.K. Gupta, Director, Materials Group, Dr D.K. Bose, Head, Uranium Extraction Division, Mr U.R. Marwah, Head, Solvent Development Section, and Mr S.C. Hiremath, (ED)(O), Mr A.K. Wechelekar, Director, PED, and Mr S.K. Nayak (SO/F) of Heavy Water Board. Earlier through the joint efforts of BARC and Heavy Water Board, a pilot plant for the production of di₂ethyl hexyl phosphoric acid (D_2EPHA) was set up at Heavy Water Plant, Talcher, Orissa. This established facility was inaugurated by Dr R. Chidambaram, Chairman, Atomic Energy Commission and Secretary to the Govt. of India, on September 3, 1999. The present work on TBP is the second exercise in the sequence. A few more extractants of immediate interest are due to follow soon.

The raw materials in this technology are available indigenously at reasonable price. The complete process is only of four steps, namely esterification, neutralization of esterification product, recovery, partial and final purification of TBP. The excess butanol, used during esterification, is efficiently recovered, purified and reused. The total loss of butanol in this process is about 5%. The yield and purity obtained are >92.0% and >99.8% respectively which are significantly higher than the reported values. TBP synthesized by this process does not suffer from commonly known drawbacks like phase disengagement and sedimentation on long storage owing to which the selectivity and extractability are increased in the solvent extraction process. In addition to this, it has been found that the TBP obtained with this technology does show better radiolytical stability and thus gives significant advantage to the purex process in radionuclide separations. Further, unlike commercially available TBP, this does not need any pretreatment before using in the solvent extraction process. All these advantages coupled with high yield speaks highly of the economic viability of the process.

BARC SCIENTIST HONOURED

◆ Dr Tulsi Mukherjee, Head, Radiation Chemistry & Chemical Dynamics Division, has been selected for the P.K. Bose Memorial Endowment Lecture Award for the year 1998. The award is given by Indian Chemical Society and consists of a citation and medallion.

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