

## 61<sup>st</sup> Republic Day of India

Address by  
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Director, BARC

"Dear colleagues,

Let me first extend a warm welcome to you all, to celebrate the 61<sup>st</sup> Republic Day of our country. As a mark of our collective salutation to our national flag, every year we assemble on this auspicious morning to celebrate the Republic day. Let me also take this opportunity to extend my greetings and best wishes for the New Year to each one of you and your family.

On the occasion of Republic Day, it is our duty to salute the members of Armed Forces who have been providing the security for this country.

As you all are aware, on this date in the year 1950, the constitution of the sovereign democratic Republic of India was adopted and the world's largest democracy was born.

While the Republic Day is a historic day in our life, it is also the day for some introspection on our part.

BARC is one of the world's largest R&D centres, where we pursue excellence in nuclear science and technology, covering a very wide spectrum of activities under a common umbrella.

Amongst the major achievements of the last year, the launching of nuclear submarine ARIHANT, bringing the reprocessing plant KARP at Kalpakkam back in operation, starting the operation of multistage flash evaporation unit of nuclear desalination project and of the 10 MeV electron accelerator deserve special mention. I shall now give a brief account of a few other notable achievements.

### **Research Reactors**

As you are aware, the research reactor APSARA was shut down on 6<sup>th</sup> June, 2009 for upgradaes. Subsequently, as part of partial decommissioning, the core has been fully defueled and the removed fuel assemblies have been safely stored in a separate water pool. The primary and secondary coolant systems were also decommissioned. The dismantling of electrical system equipment and nuclear and control instrumentation were taken up, which are also nearing completion.

The other two research reactors, CIRUS and DHRUVA continued to operate satisfactorily with high level of safety and availability.

CIRUS reactor was generally operated at 20 MW (th) with the availability factor of about 82 % during the year. The neutron radiography setup of APSARA reactor for imaging small-size material coupons has been

shifted to CIRUS and commissioned successfully. Another neutron radiography setup to facilitate post-irradiation examination of irradiated fuel pins of power reactor is being established, at one of the beam holes of CIRUS.

Research reactor DHRUVA attained the availability factor of more than 78% during the year. The reactor was generally operated at 55 MW(th). DHRUVA continued to be the major facility for radioisotope production. About 680 samples were irradiated during the year. The reactor also served as a national facility for neutron beam research. A number of research scholars from various academic institutions in the country, utilized the reactor under the aegis of the UGC-DAE Consortium for Scientific Research. DHRUVA reactor has also seen a service life of 25 years. As a result, refurbishment/ replacement of various equipment and components has now become inevitable to ensure its continued availability and safe operation and the refurbishment and replacement of important electrical equipment and switch gears are currently in progress.

Critical Facility for Heavy Water Reactors was operated on 67 occasions for conducting various experiments. As APSARA reactor was shut down for upgrades, the critical facility is also being used for nuclear detector testing and large volume sample irradiations for Neutron Activation Analysis (NAA).

While the conceptual design of high flux Multi Purpose Research Reactor (MPRR) has been completed, feasibility study for incorporation of an external spallation neutron source in the MPRR core is in progress.

### **AHWR Programme**

AHWR Thermal hydraulics Test Facility and Fuelling Machine Test Facility are being set up at R&D Centre, Tarapur. While generation of critical heat flux data in the thermal-hydraulic facility would establish feasibility of power up-rating in AHWR, performance of AHWR fuelling machine would be assessed in the other facility.

Based on the studies performed for Thorium/LEU-based fuel for AHWR, high burn up of 64000 MWD/T seems to be achievable. Though uranium and plutonium obtained from discharged fuel would still have appreciable amount of fissile content of U and Pu, it will be proliferation-resistant because of the presence of radioactive isotopes in both of them.

### **HTR programme**

A new feature of Burn-up Compensation Rods (BCRs) is introduced in the CHTR core design and detailed physics analysis has been done. The use of BCRs would help in controlling the excess reactivity during the long reactor core life, which in turn would help to reduce the worth of each control rod during reactor operation.

The Indian High Temperature Reactor is being primarily designed for production of hydrogen. The detailed physics design analysis for the 600 MWth Pebble-bed HTR is in progress. The initial core containing fresh pebbles has been designed by reducing the content of U-233 in the pebble to 4.25 %.



## Fuel for Fast Reactors

As part of the continued production of Uranium Plutonium mixed carbide fuel for FBTR, fuel pins for seven fuel sub-assemblies have been shipped to IGCAR last year, which included one Fuel Sub-assembly pin made with reprocessed plutonium from FBTR fuel. This notable event marks the closing of the fast reactor fuel cycle in India. The PFBR experimental MOX fuel pins fabricated at AFFF, Tarapur, loaded in the very centre of FBTR core, has now reached a burn up exceeding 92,000 MWd/T.

Fabrication of six million Deeply Depleted  $UO_2$  pellets required for axial breeder blanket of the first core of PFBR has also been completed. End plug welding of D-9 clad tubes using Nd – Yag laser has been qualified with fabrication of more than thousand full length MOX fuel pins, the optimum parameters for large production of PFBR MOX fuel have been finalized.

As part of metallic fuel development programme for fast reactors, a new thermo-physical property evaluation lab has been set up in the Radiometallurgy Division. Thermo-physical and thermo-mechanical properties of several Uranium Plutonium alloys and fuel-clad chemical compatibility studies are presently in progress.

## Post-Irradiation Examination

The mechanical properties of PHWR fuel clad irradiated to burn-up of 15,000 MWd/T have been evaluated, which showed about 30% loss of ductility as compared to virgin material. Two main damage processes, namely irradiation damage and hydride induced degradation appear to be contributing towards loss of ductility.

## Reprocessing and Waste Management

It is a matter of great rejoice, that all the three reprocessing plants are in operation. At KARP, Kalpakkam, a record of chopping and processing of spent fuel bundles has been achieved in the recent past. PREFRE, Tarapur continued to operate safely despite being a vintage Plant. The Plutonium Plant at Trombay operated well and processed the entire spent fuel inventory received from CIRUS & DHRUVA reactors.

At Revamping Of PREFRE (ROP), Tarapur, commissioning of various systems and equipment has made good progress. For the first time, a state-of-the-art spent fuel chopper has been deployed in this plant, to enhance the throughput.

At WIP, Trombay, modification jobs for waste concentration system have been completed and installation of sulphate separation and acid recovery systems are in progress. At WMF, Tarapur, about 200 m<sup>3</sup> of Intermediate Level Waste (ILW) has been treated by ion exchange process and about 250 m<sup>3</sup> of HLW has been concentrated to ensure uninterrupted operation of PREFRE.

The engineering scale demonstration facility, for partitioning of High Level Waste is in an advanced stage of completion at Tarapur. This facility is with the state-of-the art technology and will be a step forward in reducing radiotoxicity associated with long-lived radioisotopes, present in high level waste.

At CWMF, Kalpakkam, a facility for melt densification of plastic / polythene waste has been successfully adopted for treatment of such waste from MAPS.

### **R&D Support for Power Programme**

A Sludge Lancing Equipment (SLE), designed and assembled by BARC and supplied to NPCIL, was successfully operated for sludge removal, from all the four steam generators of the Kakrapar Atomic Power Station. About 45 kg of wet sludge was removed successfully from these steam generators.

Ultrasonic Measurement of Axial Creep (UMAC) has been developed in RTD to replace the old TMAC i.e., Technique for Measurement of Axial Creep system. The new system which reduces the time required for measurement, was handed over to NPCIL.

Ultrasonic Phased Array System for reliable flaw detection and accurate flaw characterization has been commissioned. This technology will be useful for periodic in-service inspection of critical nuclear power plant components, with minimum man-rem consumption.

The Containment Studies Facility built near Hall 7 has become operational now. Blow down tests have been conducted successfully at 30 Kg/cm<sup>2</sup> pressure and 235°C temperature. The recorded pressure and temperature transients were found to be in agreement with pre-test analytical predictions.

In a reinforced concrete framed structure, under seismic excitations, the most vulnerable zone is the beam-column joint. Experiments were performed on full-scale beam-column joints under quasi-cyclic excitation, to evaluate their performance under the event of earthquakes.

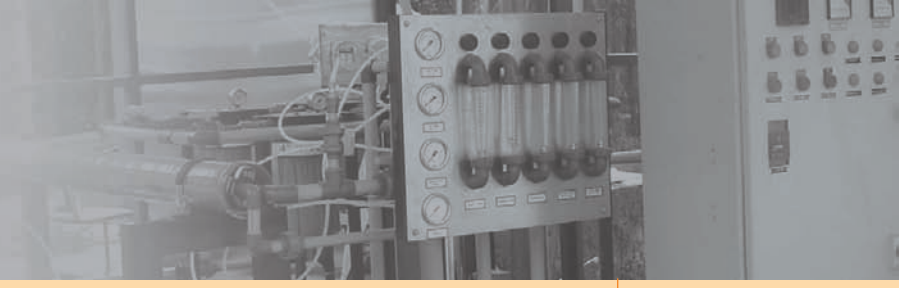
A new model of IERMON system was developed with multiple radiation detectors for enhanced performance, with particular attention to early detection of nuclear emergency. The system is now being manufactured by ECIL, Hyderabad under the XI Plan. IERMON Central Station is established at Anushaktinagar, Mumbai for centrally monitoring and managing the countrywide network.

### **Materials Research**

Several facilities, viz., fluoride effluent treatment facility, UF<sub>4</sub> production facility, Ammonia Di-Uranate (ADU) calcining facility have been successfully commissioned. A new analytical laboratory at RUMP has been made fully functional.

Process flow sheet has been successfully developed to exploit the uranium ore deposit, located at Gogi (in Karnataka). The process development studies were carried out in the Technology Development Pilot Plant (TDPP) at Jaduguda.

Beryllium components in specific shapes have been fabricated by powder metallurgy route, to meet the in-house requirement for neutron physics studies.



A processing sequence has been successfully developed for the synthesis of control rod material, boron carbide powder (enriched in B<sup>10</sup>), and its subsequent fabrication into B<sub>4</sub>C pellets, meeting the stringent specifications with respect to chemical composition, density and dimensions. 111 enriched boron carbide pellets were successfully fabricated and supplied for PFBR.

A total of 75 special boron alloy [Ti (Cr) B<sub>2</sub> & MoSi<sub>2</sub>] pellets of 95% theoretical density were synthesized, characterized and supplied for PRP.

Processes for production of bulk metallic glass and tungsten reinforced glass composites, for application as tank penetrator were developed. Bulk metallic glass has been produced in cylindrical and bar geometries by suck casting.

The technology for preparation of Ni-Ti alloys and heat shrinkable ferrules for the Light Combat Aircraft is being transferred to HAL, Bengaluru, under a tripartite MoU. The construction of a new workshop dedicated to this project, was recently completed at HAL.

BARC has initiated development and fabrication of cable-in-conduit conductor, for various configurations for Nb<sub>3</sub>-Sn based superconducting magnets, required for fusion research work at IPR. The flow sheet for this advanced superconductor fabrication has now been developed and trials are in progress.

### **Chemical Engineering**

Indian Design Description Document (DDD) for (a) Helium coolant purification system; (b) hydrogen isotope removal system from helium purge gas; and (c) tritium extraction system from Pb-Li loop was prepared for Tritium Blanket Module (TBM) of ITER. Approval was obtained from the International TBM Port Management Group for conceptual Tritium Extraction System loop design, which is a key step for sustained operation of ITER.

Indigenously developed micro cryo-cooler unit, to be used in hand-held infrared cameras, has been fabricated and tested with no load. A minimum temperature of 59 K was achieved during experiments.

The complete flow sheet for preparation of pure V<sub>2</sub>O<sub>5</sub> has been optimized and all unit operations have been individually investigated on kilogram scale. A separation cascade consisting of 8 stages of extraction and 16 stages of scrubbing with DHEHPA as extractant has been operated for producing nuclear grade Dy<sub>2</sub>O<sub>3</sub> on a laboratory scale. Purity of Dy<sub>2</sub>O<sub>3</sub> achieved with reference to Gd, Tb and lighter rare earths was over 99%.

### **Design, Manufacture & Automation**

The Centre for Design and Manufacture (CDM) has completed the design, manufacture, assembly, testing and demonstration of Linear Distancing System Assemblies as well as training of ECIL personnel against an MoU.

Bhabhatron-II machines have been finding increasing acceptance. In all, 14 such teletherapy machines have been installed in various Cancer hospitals.

**Physical & Chemical Sciences**

Equation of state of natural uranium has been determined up to a quarter megabar, through high pressure experiments carried out for the first time at EDXRD beamline of Indus-2.

Thermoelectric devices consisting of 8 pellets each of n-type PbTe and p-type TAGS-85 alloy have been fabricated. The devices have 6% efficiency and provide a power output of 4.1 watt at 300 mV.

Using an in-house process, Carbon-doped alumina has been prepared in 40 gm batches. This material is suitable for dosimetry in thermally stimulated luminescence as well as optically stimulated luminescence modes. Detailed characterization of the material is being carried out.

A double focusing neutron monochromator has been installed on the filter detector spectrometer at Dhruva and it has led to a substantial increase in neutron flux for experiments. A new neutron radiography set-up has been installed at CIRUS which is useful for nondestructive imaging of various samples.

Experiments on delayed neutron counting following photofission of U have been done, using Bremstrahlung radiation produced by bombardment of 10 MeV Electron beam on Ta foil. Decay profile of delayed neutrons from fission products was obtained from varied amounts of U-targets and yields of delayed neutrons increased with U-target amounts. These are preliminary experiments aimed at detection and measurement of U/Pu in sealed containers.

**Lasers and Accelerators**


The 10 MeV RF electron accelerator at Electron Beam Centre, Kharghar, Navi Mumbai became operational and has reached a Beam Power of 4.5kW. It has been used to produce X-rays in the energy range of 3.0 MeV to 3.8 MeV using a tantalum target placed on beam dump.

The 3 MeV DC electron accelerator was tested up to 1 MV with 6 kgs/cm<sup>2</sup> nitrogen gas pressure. An electron beam of 1 MeV at 500  $\mu$ A to 1 mA was produced. The electron beam has been scanned, extracted out of the beam window and characterized by dosimeter film.

A 9 MeV, 2kW, RF electron linac for X-ray radiography of large container scanning system is being developed in collaboration with ECIL. The system was operated to a maximum of 150 Pulse Repetitive Frequency (PRF), 2.5 MW peak forward, power and 35mA beam current. X-ray imaging experiments were conducted with different PRF and exposure times.

As part of the LEHIPA project, a test bench facility has been set up with an RF ion source, solenoids and other beam diagnostics, to understand more about low energy beam transport.

As an important step in the clean-up programme, the isotope shift between U-232 and U - 238 was measured in the spectral range of 15000 cm<sup>-1</sup> to 18000 cm<sup>-1</sup> by Fourier transform spectroscopy using specially designed Electrodeless Discharge Lamps (EDL) with 30-40 microgram quantities of uranium as the radiation source.



Design of Magnetohydrodynamic experimental facility employing mercury, to study flow phenomena at high Hartmann and Interaction parameters for Indian TBM has been completed.

Significant progress has been made in the design of 18MW electron/positron Beam Dump for the proposed International Linear Collider by BARC and the Stanford Linear Accelerator Centre, USA.

### **Electronics & Instrumentation**

A PC-based laboratory system for face recognition was developed, for carrying out robust face identification employing a facial matching technique, based on 2D Pseudo Hidden Markov Modeling (HMM) technique.

The Centre for Micro Electronics and Micro-electro-mechanical Systems (CMEMS) has been set up at Prabhadevi, in collaboration with ECIL. The centre has VLSI-CAD lab with full-suite of IC design tools and TCAD tools on robust computational platform, for fab-less design and development of semiconductor devices, process technologies and ASICs.

The hand-held Tele-ECG has been developed for Mobile as well as LAN application and supplied to Post Graduate Institute of Medical Education & Research, Chandigarh, Grant Medical College and J.J.Hospital, Mumbai, for validating its application in rural health care. The technology was transferred to M/s CHESS Medicare Pvt. Ltd., in November 2009.

New arrangements for 8 lane access control system have been implemented at the North Gate of BARC.

With the establishment of the Facility of Electromagnetics in Autonagar, Vizag, some important BARC activities have been shifted to Vizag, where a Computing Centre with a capability of 4 teraflop capacity has been successfully commissioned.

### **Desalination Programme**

The barge-mounted mobile seawater RO desalination plant developed by BARC, has been registered under the name 'SUJAL'. An MOU on custody and operation of this plant was signed with M/s. Indian Rare Earths Limited (IREL) and the plant is working at OSCOM, Orissa.

5000 litres per day capacity Electro-Dialysis Ionization (EDI) unit for ultra-pure water of <math><0.1</math> micro-siemens/cm conductivity was commissioned and being operated to generate design data. It is also being used to supply ultra-pure water to the various facilities of BARC on demand.

The multistage flash evaporation plant at Kalpakkam has become operational and the production capacity is being steadily raised to the name plate capacity.

### **Nuclear Agriculture**

Trombay Dharwad Groundnut variety TDG 39, a confectionary-grade, large-seeded variety has been released by the Ministry of Agriculture, Government of India in 2009, for commercial cultivation in northern transitional

Zone 8 and northern dry Zone 2 and 3 of Karnataka.

### **Food Technology**

A novel radiation-resistant bacterial strain was isolated from black pomfret and it was identified as a novel species of *Deinococcus* based on its characteristics. It has been named *Deinococcus piscis sp. nov.* and it has been included in the approved list of bacterial names.

The Yield of protein in soymilk produced from radiation processed (10kGy) soybean appreciably increased resulting in increased yield of tofu.

A synthetic pomegranate aroma was formulated for commercial flavouring application for the first time.

### **Radiation Biology and Health Sciences**

For the first time, the frequency of spontaneous micronuclei was estimated among the 210 newborns from a natural high background radiation area (HLNRA) using cord blood samples. This was compared with that from 61 newborn from normal level radiation background area (NLNRA). The studies concluded that elevated level of naturally occurring radiation has no significant effect on the induction of micronuclei frequency among the newborns.

Telomere length, which is reported to shorten on exposure to high doses of ionizing radiation, is a good biomarker for aging, stress and cancer. In a first study of its kind, the telomere length was estimated in 310 adult individuals, which included 233 from High Background Radiation Area and 77 from NLNRA. Again, the elevated level of natural background radiation showed no significant effect on telomere length among the adult population.

### **Radiation Medicine**


The protocols for the synthesis of two Fluorine-18 labeled radiopharmaceuticals namely, <sup>18</sup>F-MISO (fluoro-miso-nidazole) for imaging areas with low oxygen content in tumours and <sup>18</sup>F-thymidine for imaging tumours (cell proliferation) have been standardized. These two compounds have been approved by the Radiopharmaceuticals Committee for commercial production which may start in a few months.

### **XI Plan Activities**

We are at the moment more than half way through our XI<sup>th</sup> plan project activities. It is time to examine very critically the progress of our various projects, both financial and physical, so as to fully gear up to achieve the deliverables at the end of the Plan period.

I shall urge my colleagues to extensively use PARINAY for reporting the progress of work and for making an objective assessment of our progress towards achieving the goals defined in respective project reports.

I am happy to say that the OCR system adopted by BARC has been very successful and almost every officer



of this Centre could submit his last year's OCR in time. Efforts are on, to further improve the OCR system based on suggestions received from some of you.

We are all deeply saddened by the unfortunate fire incident in the Modular Laboratories on 29<sup>th</sup> December, 2009, when two young Ph.D students, Mr. Umang Uday Narayan Singh, Senior Research Fellow and Mr. Partha Pratim Bag, Junior Research Fellow lost their lives. On this occasion, we also pay our homage to the departed souls. It is time for all of us to introspect and ensure that such an incident must never take place in the centre.

I am urging all my colleagues here to scrupulously follow the safety guidelines and procedures laid down by the BARC Safety Council from time to time and give due priority to safety. I strongly appeal to all of you to be extra vigilant and bring any lapses, to the notice of the appropriate authorities for stern action against the defaulters.

### **Physical Protection**

Physical protection of our Centre and its various installations is of paramount importance. I am sure, all my colleagues will understand that the concern of security has further increased in the present time. I strongly urge our Fire Service personnel to maintain a constant vigil on the various establishments of our centre and strive to improve their coordination with security and the concerned Divisions.

I also compliment all officers and staff of our Centre for extending their cooperation with the security personnel in discharging their duties effectively for implementing the higher level of security procedures. Finally, I urge all my colleagues in our Centre to remain vigilant and alert in the present environment.

### **Landscape & Cosmetic Maintenance**

The contribution made by the personnel of our Landscape & Cosmetics Maintenance Section is aptly demonstrated by the beautiful ambience of this venue.

### **Conclusion**

While concluding my address, I would like to emphasize that we have plenty of challenges ahead. With the Bhabha Centenary Year celebrations coming to an end, it should be our prime objective to pursue excellence, by synergising the efforts of all of us in BARC – scientists, technicians and administrators. I am sure we will be able to rise to the occasion to meet future challenges in a manner consistent with the traditions of BARC.

Friends, finally on this very special day, let us firmly resolve and rededicate ourselves to continue our pursuit of excellence in the frontier areas of nuclear science and technology, for the betterment of the lives of our people.

**Jai Hind "**