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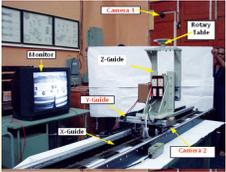
**BARC**  
NEWSLETTER

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BY DISC SPRINGS INSIDE THE  
SHUT-OFF ROD GUIDE OF THE  
AHWR 'CRITICAL FACILITY'

LINEAR DISTANCING SYSTEM  
FOR CALIBRATION OF  
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# REDUCTION OF SHOCK LOAD BY DISC SPRINGS INSIDE THE SHUT - OFF ROD GUIDE TUBE OF THE AHWR 'CRITICAL FACILITY'

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&

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## Introduction

The 'Critical Facility' (CF) is a research reactor being commissioned at BARC, Trombay to facilitate reactor physics experiments, related to advanced PHWRs and the Advanced Heavy Water Reactor (AHWR). Reactor shutdown system consists of six fast-acting mechanical shut-off rods (SRs). Under normal reactor operation, all the shut-off rods are parked above the reactor core. On reactor trip, all SRs fall freely into the core. During reactor start-up, shut-off rods are withdrawn, one rod at a time, in a predetermined sequence at a given withdrawal speed. This is to ensure reactivity addition rate from reactor physics design. In case of CF, on actuation of reactor trip, moderator is also dumped to a predetermined level, giving additional shut down margin.

An electromechanical cable-winch type drive mechanism, called Shut-off Rod Drive Mechanism (SRDM), is used to impart desired motion to the shut-off rods (absorber element). The design of SRDM adopts a fail-safe, replaceable and simple criterion, ensuring high reliability in operation. The drive mechanism is custom-built to meet the technical specifications for given reactor layout. Being a safety critical equipment, SRDM design is qualified for reactor use through prototyping and life-cycle testing of the prototype on full-scale test facility.

Cadmium is used as an absorber and this is sandwiched between two Aluminium tubes. The absorber element moves inside the guide tube, which has closed bottom

end in 'CF'. The absorber element is attached to the mechanism through stainless steel wire rope. Weight of the absorber element is about 8 Kgs. and the total stroke length is 2400 mm.

The absorber assembly consists of absorber element, guide tube locator, guide tube, push tube sub-assembly and disc spring sub-assembly. Fig. 1 shows cross sectional drawing of the absorber assembly used in 'CF'. As can be seen, the guide tube passing through the guide tube locator, rests on the girder, which is a component of the reactor structure.

In case of a rope-snap accident, when the absorber element is parked at the TOP (an element of 8 Kgs. load falling by about 2500 mm height), the result is a huge shock load both to the guide tube and the girder. In order to reduce this shock load, a disc spring assembly is used as a shock-absorbing device, which rests at the bottom of the guide tube. This paper deals with the design of the disc spring assembly and experimental validation to ensure its effectiveness in reducing the shock load experienced by the guide tube and the girder of 'CF'.

## Shock load experienced by the guide tube: calculations

The guide tube is a Class-I reactor component and is designed as per ASME Section III, Sub-section NB. Service conditions are taken as per para NCA 2142 of ASME

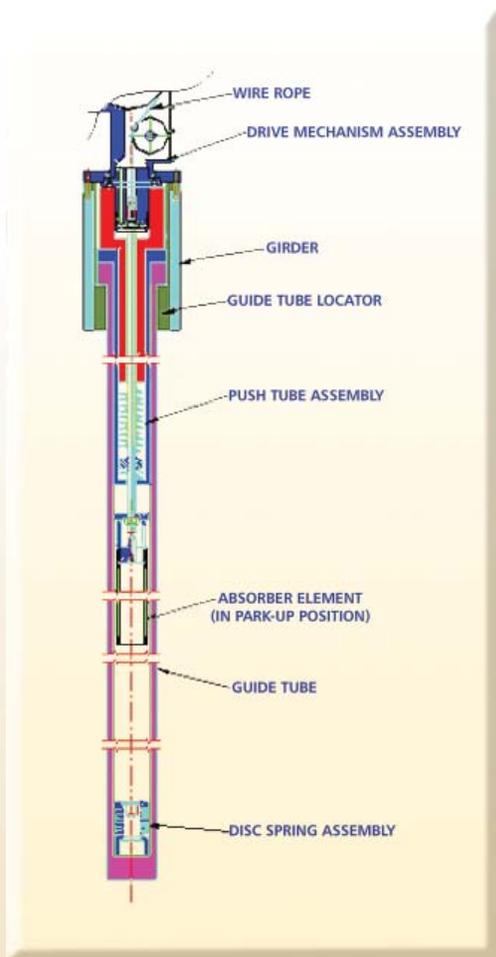


Fig. 1: Shut-off rod assembly for 'CF'

Section III, Div. I Sub-section NCA. The design accounts for level-B loading, under a postulated rope snap, from top parking position of the absorber element.

The guide tube material is Aluminium (Grade: 57S) of 78 mm ID, 110 mm OD and 5354 mm long. In case of postulated accidental event of rope snap, when the shut-off rod (about 8 Kgs) is in the top parked condition (rod fall from the height of about 2500 mm), the impact load  $W_i$  experienced by the guide tube is calculated as:

$$W_i = W \left[ 1 + \sqrt{1 + \frac{2h.A.E}{WJ}} \right]$$

Where,  $W$  = Weight of falling element,  $h$  = height of fall,  $A$  = Cross-sectional area of guide tube,  $E$  = Young's modulus of elasticity of guide tube material and  $l$  = length of guide tube.

The calculated impact load on the guide tube is 15,700 Kgf. The guide tube locator and the girder of the reactor will also experience the shock load.

### Design Considerations of Disc Spring Assembly

The disc spring assembly is used at the bottom of the guide tube, to reduce the impact load experienced by the guide tube and the connected parts under rope snap condition. The compact disc spring assembly is designed to fit at the bottom of the guide tube. Fig. 2 shows a photograph of the disc spring assembly.



Fig. 2: Disc springs and disc spring assembly

A disc spring type of assembly was chosen for this purpose, because of the following inherent advantages:

- High Load / Space ratio
- Short axial length when installed

- Combination use in modular spring element
- High energy storage capacity
- Fail-safe capability, with combination stacks of Discs
- Uniform annular loading
- Symmetrical component, ideal for rotating applications
- Non-tangle characteristics which make automatic assembly easy.

The ability to change the Force vs Deflection characteristics, by varying the cone height to thickness ratio, is a useful feature of the disc spring. Fig. 3 shows a typical disc spring.

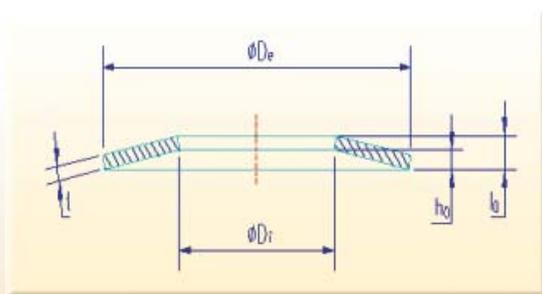


Fig. 3: A typical disc spring

Fig. 4 shows Force vs Deflection curves of the disc spring with different cone height-to-thickness ratios. Up to a ratio of 1.5, the disc springs may safely be taken to be 'flat' or stacked in columns.

The disc spring, to be accommodated in the guide tube, is selected with  $D_e = 71$  mm;  $D_i = 36$  mm;  $t = 2$  mm;  $h_0 = 2.6$  mm and  $l_0 = 4.6$  mm. The disc spring assembly consists of 20 such springs stacked together in series, as shown in Fig. 5. Experimental results for Force vs Deflection for the Disc Spring assembly (stack of 20 in series) are given in Fig. 6.

Spring stiffness (K) of a single disc spring =  $2.636 \times 10^6$  N/m.

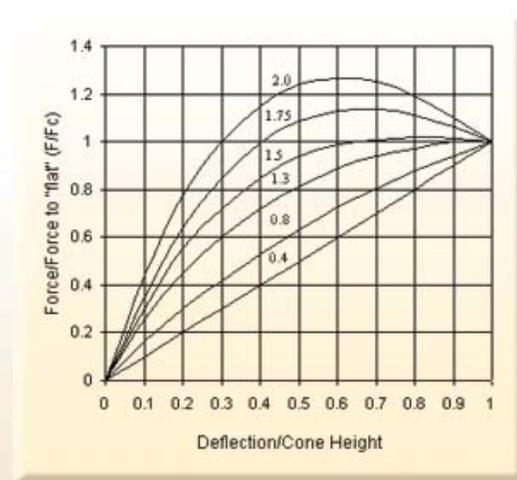


Fig. 4: Force vs Deflection for different ( $h_0/t$ ) ratio

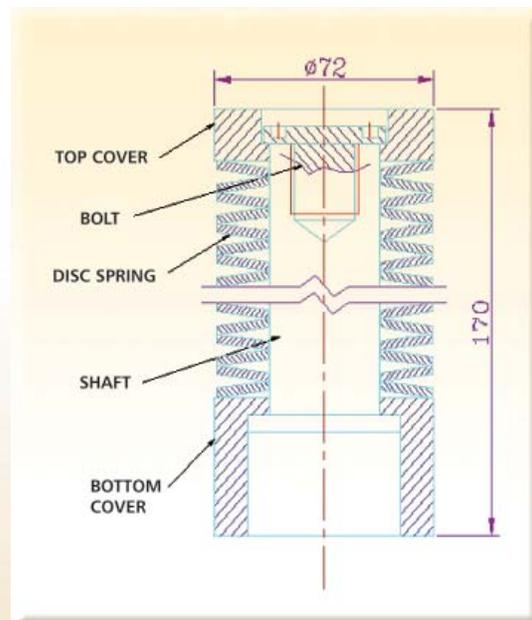


Fig. 5: Shock absorbing disc spring sub-assembly

Effective stiffness ( $K_{eff}$ ) for the assembly =  $131.8 \times 10^3$  N/m (20 disc springs in series as shown in Fig. 5)  
Total deflection of the disc spring assembly  $x = 52$  mm.

So, energy absorbed by the assembly  $E_{sp} = \frac{1}{2} Kx^2 \approx 178$  J  
Maximum potential energy of the absorber rod  $E_{ab} \approx 196$  J (assuming rope-snap occurs when the rod is at 'Parked UP' position).

Energy absorbed by Guide Tube  $E_{gt} = 18$  J

Load experienced by the guide tube (In case of rope-snap and disc spring assembly in place) =

$$\sqrt{2 \cdot E_{gt} \cdot K_{gt}} = 4700 \text{ Kg}$$

Where,  $E_{gt}$  and  $K_{gt}$  are Energy absorbed and Stiffness of the guide tube, respectively.

For simplification and conservative calculation,  $K_{eff}$  has been taken as constant, upto 75% of deflection, from the actual curve. However, the actual energy absorbed by the spring, will be more than the calculated value as

is evident from the characteristic curve (Fig. 6). Also, the guide tube absorbs some amount of energy, which further reduces the impact load experienced by the girder. This fact has not been taken into account, while calculating the load experienced by the girder.

### Disc Spring Design Analysis Through Experiment

Experiments were carried out with a dummy absorber element with similar size and weight as that of the actual element. The dummy rod was repeatedly dropped from different heights on the disc spring assemblies (in different combinations). The impact shock experienced by the dummy element, guide tube and the girder were measured by accelerometers, mounted on individual components as shown in Figs. 7, 8 and 9. The accelerometer mounted on the dummy element, travels along with the element during every drop. The accelerometer mounted at the bottom of the guide tube measures resultant shock, after attenuation by the disc spring assembly. The difference in the shock amplitudes measured by the element and the guide tube, gives the

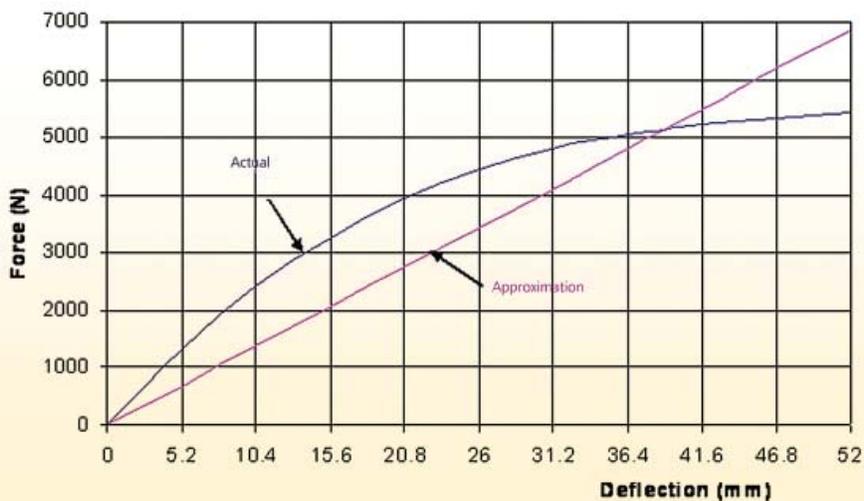


Fig. 6: Force vs Deflection curve for disc spring assembly



Fig. 7: Accelerometer attached to the dummy element and the top side of the guide tube



Fig. 8: Dummy element with accelerometer is being dropped into the guide tube



Fig. 9: Accelerometer attached to the bottom side of the guide tube

measure of shock absorbed by the disc springs. Design values and experimental results for final disc spring assembly (for reactor use) are presented here (disc spring assembly consisting of 20 disc springs of 2.0 mm thick stacked as shown in Fig. 5).

The natural frequency of the disc spring assembly plays an important role in the dynamics of shock absorption. The natural frequency was experimentally obtained by subjecting the spring assembly to sweep sinusoidal excitation on an electro-dynamic shaker. The measured natural frequency of the spring assembly was found to be 104 Hz as shown in Fig. 10.

Typical shock amplitude, seen by the dummy element, for the drop height of 2000 mm on spring assembly, is shown in Fig. 11. The shock response spectrum for the spring assembly is shown in Fig. 12. The spectrum shows the shock absorbing capacity of the disc spring assembly.

The shock amplitudes measured on the three components (dummy element, guide tube and the girder) are given in Table 1.

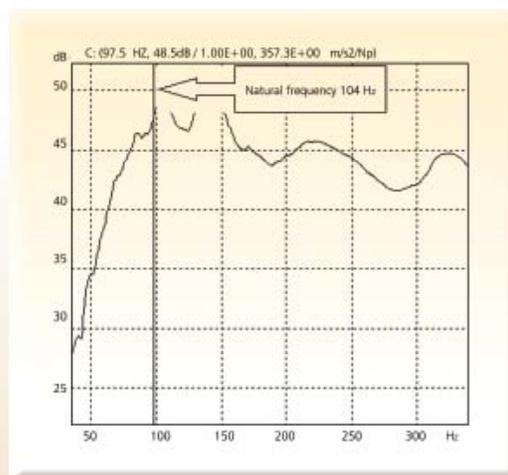


Fig. 10: Frequency response function for disc spring assembly

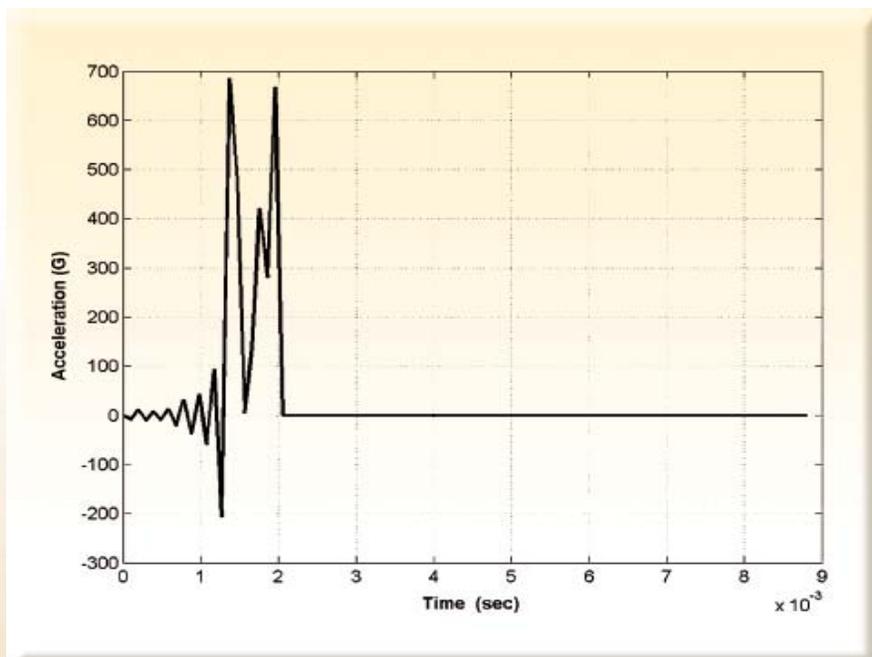


Fig. 11: Typical shock amplitude seen by the dummy element (Drop Height of 2000 mm)

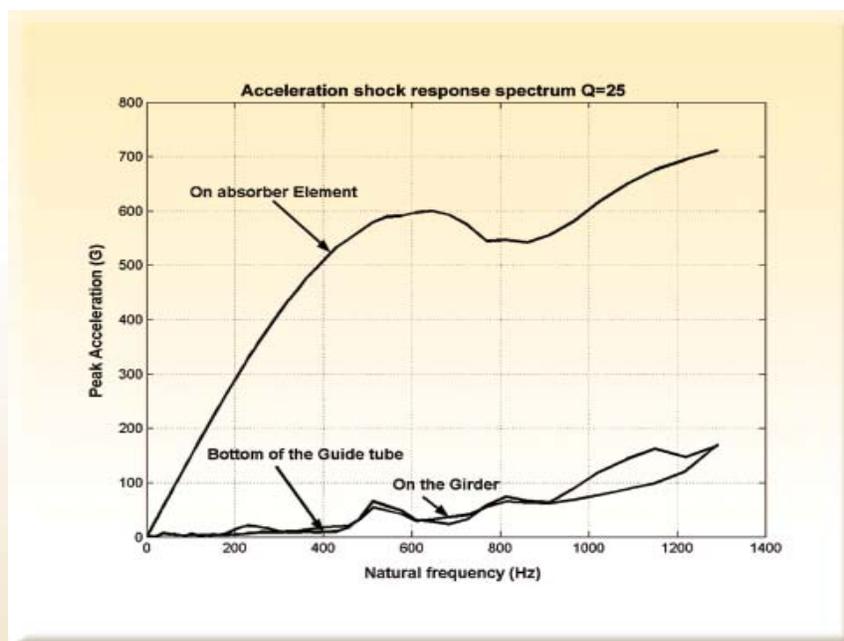


Fig. 12: Shock response spectrum of Disc Spring Assembly

Table 1: Maximum shock acceleration amplitudes for disc spring assembly

Drop Height (mm)	Maximum Acceleration Values (g)		
	Guide tube Bottom	Girder Top	Absorber element (Dummy)
500	75.19	57.86	528.58
1000	111.90	73.97	598.18
1500	157.49	163.63	551.51
2000	174.28	208.53	685.25
2500	220.01	200.80	576.50

### Conclusion

Snapping of the wire rope is a highly unlikely event, that can be expected during the lifetime of the reactor. Nevertheless, the postulated event has been accounted for in the final design. The worst position for the rope snap is, when the element is parked at the top of the core, wherein the free fall height for the element is 2.5 meters. Such a fall is estimated to give a shock load of 15,700 Kgf on the guide tube and the girder (without disc spring assembly).

With the disc spring assembly in place, the experimental shock load was measured to be about 1,760 Kgf on the guide tube and about 1,600 Kgf on the girder. The experiment reveals the effectiveness of the disc spring assembly in reducing the shock load significantly, in case of a rope snap incident. The experiment was repeated several times to ensure consistent test results.

The experimental results also show that the calculated value of the shock load is on the conservative side.

### Additional Reading:

1. "Test report on life-cycle testing of prototype shut-off rod drive mechanism for Critical Facility", Report No.: DRHR/CMS/CF/2006/02, June 2006.
2. N. Dharmaraju and A. Rama Rao, "Seismic analysis of shut-off rod absorber assembly for AHWR Critical Facility", Report No.: RED/VLS/04-05/04, April 2005.
3. N. K. Singh, M. K. Mishra, N. S. Dalal, G. Veda Vyas, C. B. Kothari, D. N. Badodkar, Manjit Singh, "Design and development of shut-off rod drive mechanism for Critical Facility", BARC Newsletter, No. 247, August 2004, pg. 1-10.
4. Earthquake resistant design of nuclear facilities with limited radioactivity inventory: IAEA TECDOC-348 (Revised Draft of March 1999).
5. AERB Safety Guides on 'Safety critical systems' (AERB/SG/D-10); on 'Core Reactivity Control' (AERB/SG/D-7); on 'Design Basis Events' (AERB/SG/D-5).

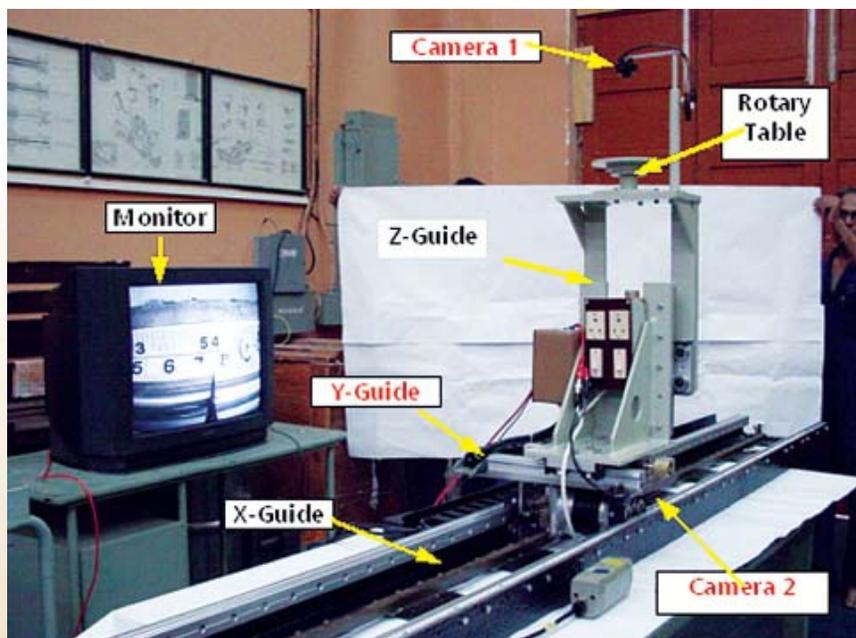
## LINEAR DISTANCING SYSTEM FOR CALIBRATION OF RADIATION DETECTORS

Centre for Design and Manufacture

This equipment has been designed and manufactured at the Centre for Design and Manufacture, BARC in collaboration with the Radiation Safety Systems Division. This equipment has been supplied to the Indian Army base workshops at Delhi and Pune and to the Health Physics Unit, TAPS, BARC.

This nifty equipment is useful, to remotely position any object to within an accuracy of 1.0 mm over X-axis travel of 2735mm. This system is explicitly designed to calibrate radiation detectors for their performance and sensitivity. The equipment has a dual camera system for remote viewing. The reading on the radiation detector, which is placed on the instrument table, is viewed on a

remote monitor and is recorded using Camera-1 (Fig. 1). The detector is positioned at various distances (along X-axis) along the direction of the radiation beam. The position reading on a linear scale (on X-axis) is viewed and recorded, using Camera-2. Since the radiation source has to be exposed during calibration of the detector, personnel are prohibited in the vicinity of the equipment and the calibration is remotely done, using a tele-operated switching circuit. This device is used for calibration of gamma ray detectors, and has to be installed in an adequately shielded room with proper radiometry dome from the outside. The instrument platform has four motions, viz. Rotational, X, Y and Z,



Linear Distancing System

out of which only X travel only is motorized. Other movements are required only during the initial alignment of the detector with the incoming gamma rays. This alignment is accomplished in the "shutter off" condition of the radiation source. After initial alignment, the detector is exposed to gamma rays at varying and known

(X) distances and the corresponding detector's scale reading is seen on the remote monitor and recorded. The detector carriage structure is made of Aluminium material, to avoid any back scattering which would affect the reading of the detector. The technical specifications of the system are given below.

### Technical Specifications

- Total X-Travel (Sampling direction): 2735 mm motorized rack and pinion drive with geared synchronous motor. A linear scale is provided along X-axis.
- Total Y-Travel: 135 mm, manual screw drive.
- Total Z-Travel: 150 mm, manual screw drive.
- Rotary table (optional): 150 diameter manual movement for 360 degrees.
- Maximum height of the system: 1100 mm from ground level.
- Maximum width of the system: 400 mm
- Total weight: 200 Kg.
- No. of camera mounts: 2 CCD cameras with video output. One is for reading X-axis position on the linear scale and the other is for reading radiation detector scale.
- Camera interface: auto/ manual channel switcher with video output socket.
- Viewing system: TV Monitor or a PC monitor with video input
- Positional accuracy: 1 mm on X-axis, 0.2 mm on Y and Z axis.
- Electrical cable harnessing: Polyurethane cable drag chain.
- Travel constraints: Two limit switches on two extreme ends of X-axis travel.
- Alignment with source: low power laser source
- Source type:  $\text{Co}_{60}$  or  $\text{Cs}_{137}$
- Controls: tele-operated from operator's room
- Material of construction: To minimise Gamma scattering, components in the vicinity of detector table are remotely made of Aluminium alloy.
- Prerequisites: adequate biological shielding of the detector room, accepted after radiometry tests.

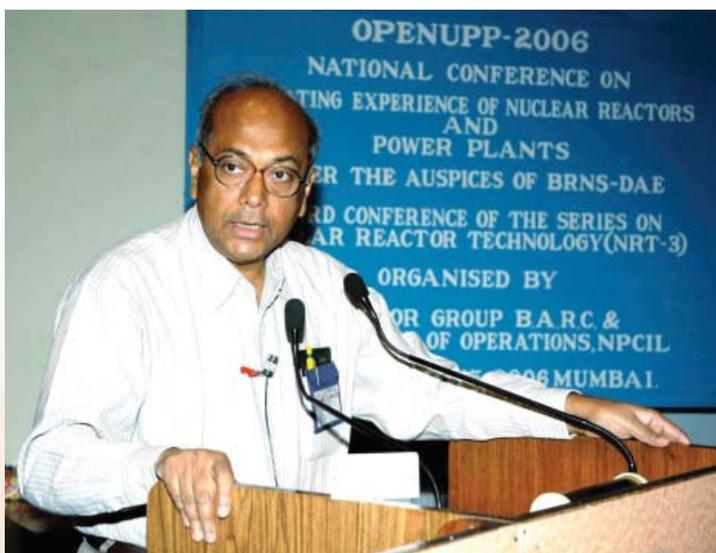
## NATIONAL CONFERENCE ON OPERATING EXPERIENCE OF NUCLEAR REACTORS AND POWER PLANTS: A REPORT

A three-day National Conference on Operating Experience of Nuclear Reactors and Power Plants (OPENUPP-2006) was held at the Central Complex Auditorium, BARC, Mumbai from 13th to 15th November, 2006. The conference was jointly convened by Mr S.K. Agarwal, Head, Reactor Operations Division, Reactor Group, BARC and Mr Subhash Mittal, Director (Operations), NPCIL under the auspices of the Board of Research in Nuclear Sciences. The conference provided a platform to the scientists and engineers to share the experience gained over the years, in the field of Operations and Maintenance (O&M) of nuclear reactors and power plants. Dr Srikumar Banerjee, Director, BARC delivered the inaugural address. Dr Anil Kakodkar, Chairman, Atomic Energy Commission was the Chief Guest at the inaugural function and addressed the gathering. Dr Kakodkar highlighted the

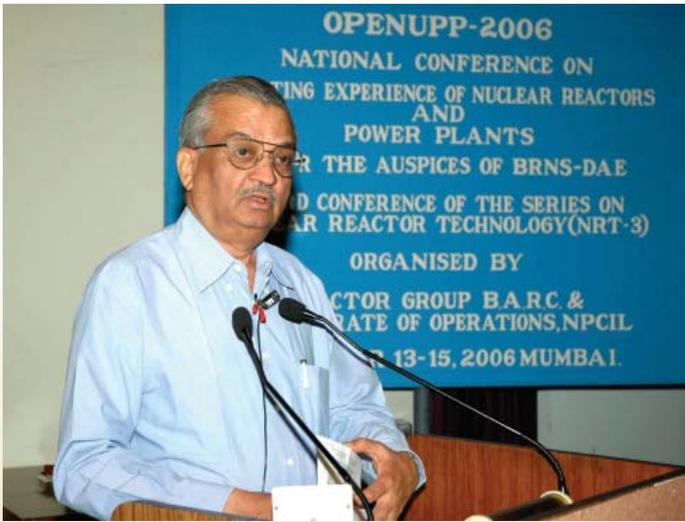
importance of such conferences in the management of existing plants and in the design of future ones. He emphasized the need to include feed back gathered during such conferences in to a central electronic data base, such that, it can be accessed by each and every plant operator online, as and when needed. He also stressed the need to employ knowledge-based resources like simulators for modeling of futuristic systems and optimisation of processes to reduce the operating costs as much as practically achievable. While touching upon the need to upgrade and update O & M procedures and practices, he also suggested that O&M community has to prepare itself to face the problems arising out of transitions in future O&M practices. From present technologies (Pressurized Heavy Water Systems) to emerging technologies like fast reactor technology,

compact high temperature technology, safe passive system technology, accelerator driven sub-critical system technology - that will enter the commercial domain in the near future. He complimented the organisers for timely conduct of this conference and in bringing out the pre-print of the compiled papers on O&M experiences in book form.

Mr S.K. Sharma, Chairman, Atomic Energy Regulatory Board released the pre-print of the papers presented at the Conference. Mr S.K. Jain, Chairman & Managing Director of the Nuclear Power Corporation of India Ltd. delivered the presidential



Dr Srikumar Banerjee, Director, BARC  
inaugurated the conference OPENUPP-2006



**Dr Anil Kakodkar, Chairman, AEC and Secretary DAE delivering the chief guest address**

address. Mr Rakesh Nath, Chairperson, Central Electricity Authority (CEA), Mr K. Prakasa Rao, Executive Director (Engg.), NTPC and Mr Masayoshi Takahashi, WANO delivered key note addresses.

The Chairman & Managing Director, NPCIL, traced the evolution of nuclear power industry in India, its early problems and constraints and its growth from infancy to robust maturity with the promise of a bright future and readiness to share the burden of fulfilling the nation's energy needs.

Mr Rakesh Nath, Chairperson, CEA spoke on the present energy scenario of the country and future plans to reach an installed capacity of 2,00,000 MWe by the end of the XI Plan. He also highlighted

various efforts towards energy conservation; reduction of transmission and distribution losses as also plans for the refurbishment and renovation of existing plants, to increase plant efficiency and plant load factors.

Mr S. Duraisamy, Reactor Superintendent, Dhruva and Conference Secretary proposed the vote of thanks.

Over 500 participants attended the three day conference. Twenty two invited talks on Core Physics and Fuel management, Commissioning of facilities and systems, Operational experience, Fuel handling, Computer-based Control systems, Passive and

innovative designs for future plants, Chemistry control, Radiation emergency preparedness etc were delivered. An impressive exhibition was also set up by fourteen exhibitors from the power industry.



**Chairman AEC and secretary DAE inaugurating the exhibition and interacting with the exhibitors**

## BRNS THEME MEETING ON MODELLING OF GROUND WATER CONTAMINATION

The Health, Safety and Environment Group, BARC organised the BRNS Theme Meeting on 'Modelling of Groundwater Contamination' between 8-12 January 2007, at the CT&CRS Building, Anushaktinagar, Mumbai. The objectives of the meeting were to enhance and share knowledge on existing practices and advanced techniques, on groundwater contaminant transport modelling, among scientists and engineers from the different units of DAE and from academia. This meeting examined and discussed a range of subjects including hydrogeology, subsurface flow, aquifer tests, radionuclide transport in porous media and related analytical and numerical techniques. These objectives have a special relevance to radioactive waste management throughout the nuclear fuel cycle. The Theme Meeting was organized with the above preambles in mind, to impart in-depth knowledge, about the subsurface environment and modelling techniques on the participants.

The Theme Meeting was inaugurated by Dr Srikumar Banerjee, Director, BARC and chaired by Mr H.S. Kushwaha, Director, Health, Safety and Environment Group, BARC. Dr P. P. Chandrachoodan, Programme Officer, BRNS welcomed the gathering and Mr V.D. Puranik offered the vote of thanks. Dr Banerjee in his inaugural address opined that the Theme Meeting was organised to cater to the different requirements of the DAE. He stressed the relevance of ground water modelling at the different stages of nuclear fuel cycle; starting from the front end fuel cycle to the back end fuel cycle. Each stage has different requirements in terms of design and operation of radioactive disposal facilities. The concept of ground water modelling is simple as it consists of mainly source, pathways from source to the environment and its impact. However, the interaction between ground water and source is a complex phenomenon and can take place in different ways



**Dr Srikumar Banerjee, Director,  
BARC inaugurating the BRNS Theme Meeting**

including diffusion controlled kinetics. Geochemistry is very important in evaluating this interaction as it determines the different oxidation/reduction states of the subsurface environment. The importance of geochemistry is quite evident in the mineralization of uranium in narrow belts wherein preferential ground water flow occurred previously. He also emphasized the importance of water resources and their development for sustaining civilization. In India water harvesting was practised since ancient times. He said that in Mumbai, more than hundred times the water quantity requirement is being wasted as overland flow and it was a major drawback in the water resource development programme. He pointed out the efforts of the Isotope Applications Division, which identified the recharge areas in a water scarce locality in Uttaranchal through isotope tracer applications. Proper measures were taken, to increase the recharge in the identified recharge areas. Now the extinct springs have reappeared and new springs are also being developed. Dr Banerjee pointed out the need to develop deep geological repositories and related modelling in near

future. While designing and constructing such repositories, care should be taken to see that the groundwater should not be contaminated. He raised many issues in the field of ground water modelling such as long-term prediction, complicated geochemistry, effects of retardation, different modes of source releases and validation of models. Finally he stressed the need for organizing more such Theme Meetings in future, as short term courses.

Mr Kushwaha in his presidential address explained the activities of different divisions in BARC in the field of groundwater modelling. He emphasised the need for geophysical investigations, to obtain detailed characterisation of waste disposal sites. He said that the Theme Meeting was organised with a hope that the participants would be able to enhance their knowledge on various aspects of hydrogeology and ground water modelling from experts and thus they would be able to continue their pursuit in ground water modelling studies, with a new understanding.

About 35 participants from BARC and other DAE units attended the Theme Meeting. The units included EAD, HPD, RSSD, IAD, BETDD, ROD from BARC; NPCIL,

IGCAR and AERB from other DAE units. All these divisions and units are directly or indirectly involved in many aspects of radioactive waste management and related ground water modelling.

The experts who took part in the deliberations include: Prof. Elango from Anna University, Chennai; Prof. Viswanadham and Prof. Eldho from IIT, Mumbai; Dr Senthil Kumar from Central Ground Water Board, Ahmedabad and Mr H. S. Kushwaha, Dr Y. S. Mayya, Dr R. N. Nair, Dr Brindaban Ghosh and Dr R. R. Rakesh from BARC.

The topics that were deliberated in the Meeting include:

- Basics of hydrogeology
- Introduction to ground water modelling
- Well hydraulics and pumping tests
- Data requirement
- Numerical modelling of contaminant transport in porous media
- Ground water modelling using finite element method
- Analytical solutions of advection-dispersion equations
- Solution techniques for non-linear differential equations
  - Modelling migration of radionuclides from near surface radioactive disposal facilities
  - Radionuclide transport through fractured porous media
  - Centrifuge model tests on pollutant movement in soils.

Apart from these topics, the Theme Meeting conducted hands-on exercises on various topics in hydrogeology and ground water modelling. The ground water modelling software, "GMS" was demonstrated to the participants.



**Mr H.S. Kushwaha, Director, HS&E Group delivering the presidential address (sitting from left: Dr R.N. Nair, EAD; Mr V.D. Puranik, Head, EAD; Dr S. Banerjee, Director, BARC; Dr P.P. Chandrachoodan, Programme Officer, BRNS)**

## INTERNATIONAL BLIND PROBLEM EXERCISE ON MODELLING OF PHWR FUEL BEHAVIOUR AT EXTENDED BURNUP

A blind problem exercise was organised on PHWR fuel modelling, to investigate the predictive capability of existing codes, for their application at extended burnup and to identify areas for improvement. The blind problem for this exercise, was based on data generated with a PHWR fuel bundle, irradiated in Kaiga Atomic Power Station Unit 1 (KAPS-1) up to about 15,000 MWd/TU and subjected to detailed post-irradiation examination in PIED hot cell facility.

The participants of this exercise were provided with a data package consisting of (i) design, fabrication and pre-characterisation data of fuel, cladding and fuel pins of the bundle; (ii) irradiation power history of the fuel pins of the bundle and (iii) coolant temperature and fast neutron flux data for irradiation period.

The participants were required to provide blind predictions of fuel temperature, fission gas release, internal gas pressure and other performance parameters. The actual experimental PIE results were withheld and were revealed to the participants only after receiving the results of their blind calculations of the problem.

Eleven computer codes from seven countries including India were tested in this exercise. Table I shows the list of codes / countries which participated in this exercise. The results of the blind exercise were presented and discussed at the IAEA Technical Meeting on PHWR Fuel Modelling held at Mumbai during December 5 - 8, 2006. During this Technical Meeting, an entire day was dedicated to the blind problem exercise and analysis of



Fig.1: A session in progress at the IAEA TM on PHWR Fuel Modelling

results. Fig.1 shows a technical session in progress at the IAEA meeting.

An analysis of the results of code predictions was presented by Mr D.N. Sah, Head, PIED, BARC. The irradiation power histories and the corresponding blind predictions of fuel centerline temperature, by various codes in outer fuel pin, are shown in Fig.2. Most codes showed an almost similar trend of temperature evolution, during the irradiation period. However, the fission gas release (FGR) predictions showed a large variation, with most of the codes underpredicting FGR and the end-of-life pin pressure.

From the discussions held at the IAEA Technical Meeting, several points emerged with regard to the differences in FGR predictions:

- Microstructure of the pellet and its influence on FGR
- Minor impurities and their influence on thermal conductivity of the fuel
- Uncertainty in pin power data
- Method of modelling FGR in each code Based on the discussion, the following recommendations were made:
- Recalculation of the cases accounting for uncertainty in thermal conductivity and pin power
- Irradiation of PHWR fuel pin with in- pile instrumentation for temperature and internal gas pressure measurement
- Detailed characterization of microstructure and chemistry of fuel and measurement of thermal conductivity / diffusivity of fuel

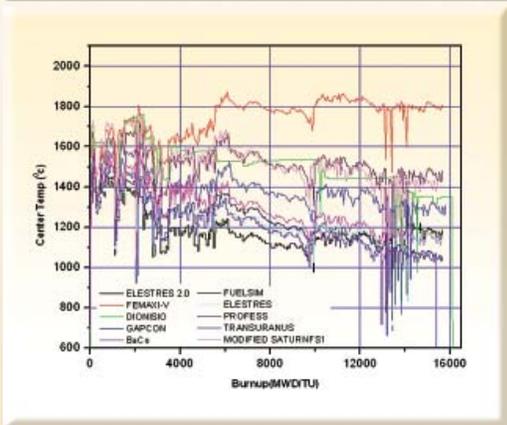
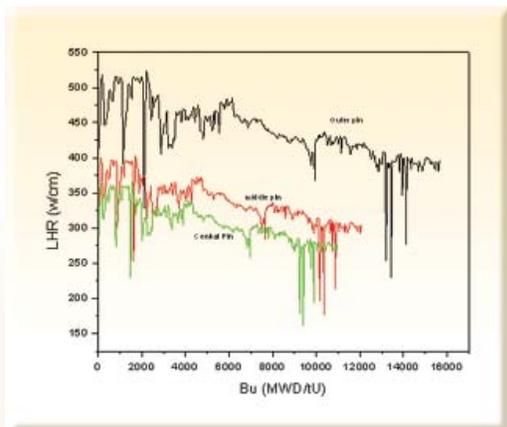


Fig. 2: Irradiation power histories and the corresponding fuel centreline temperatures in the outer fuel pin predicted by various codes.

Table 1: List of computer codes used in the blind problem exercise

S. No	Name of Code	Organisation	Country
1.	PROFESS	BARC	India
2.	ELESTRES 2.0	AECL	Canada
3.	FEMAXI- V	NRI Rez plc	Czech republic
4.	DIONISIO	CNEA	Argentina
5.	GAPCON	BARC	India
6.	BaCo	CNEA	Argentina
7.	TRANSURANUS*	INR	Romania
8.	FUELSIM*	INR	Romania
9.	SATURN-FS1	IGCAR	India
10.	ELESTRES	KAERI	Korea
11.		CIAE	China

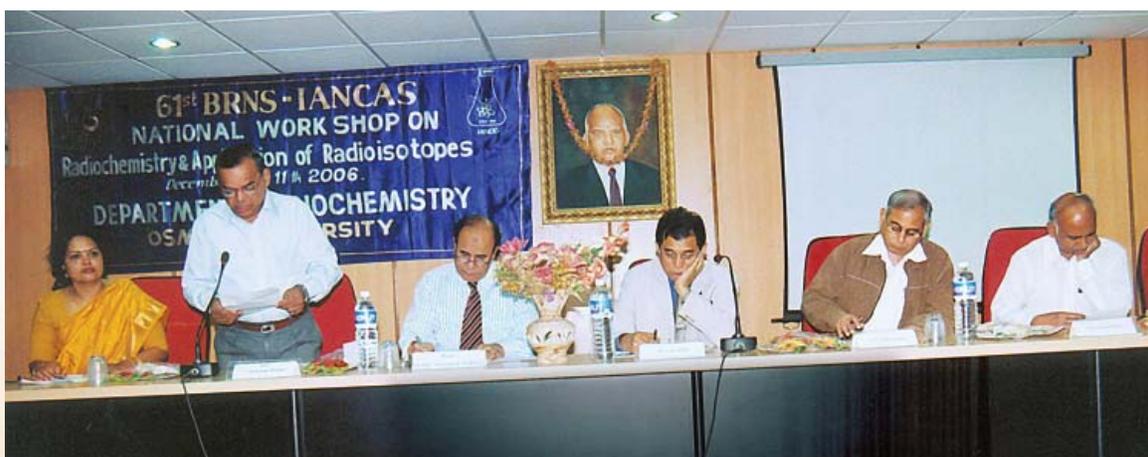
\*only outer pin analysed

## BRNS-IANCAS NATIONAL WORKSHOP ON "RADIOCHEMISTRY AND APPLICATION OF RADIOISOTOPES": A REPORT

The 62<sup>nd</sup> BRNS-IANCAS National Workshop on "Radiochemistry and Application of Radioisotopes" was held at the Department of Biochemistry, Osmania University, during December 4-11, 2006. While inaugurating the workshop Prof. Lalji Singh, Director, CCMB, Hyderabad enumerated several applications of radioisotopes in various fields and their active role in future. Presiding over the function Prof. Siddique, Vice-Chancellor, Osmania University, complimented the department of Biochemistry for organising this workshop and appreciated the efforts of the organisers, in training the teachers in the basics of Radiochemistry and the use of radioisotopes. Prof. Venkata Ramana Devi, Head, Department of Biochemistry, welcomed the participants. Speaking on the occasion Dr V.K. Manchanda, President, IANCAS referred to various popular programmes undertaken by IANCAS, during the Silver Jubilee year of the association, in meeting its objective of popularizing

the subject of Radiochemistry, among the teachers of universities/colleges. He also explained the participants about the promotion of research projects from universities by BRNS. Dr G.A. Rama Rao, Secretary, IANCAS briefed the participants regarding the contents of the Workshop. The inauguration concluded with a formal vote of thanks by Prof. Sobhanaditya, chairman, Biosciences, Osmania University.

53 teachers with a majority of them from biosciences participated in the Workshop. Apart from the six resource persons who conducted the workshop with theory lectures in the morning and experiments in the afternoon, there were six guest lectures by Dr Sanjeev Kumar, CCCM, Hyderabad, Dr N. Shivaprasad, BRIT, Dr K.S. Reddy, NABTD, Dr V.K. Manchanda and Dr K.L. Ramakumar, BARC. The lecture on 'Non-fossil fuel resources and their



At the Inauguration: (L-R) Prof. Ms Ramana Devi, Head, Dept. of Biochemistry, Prof. Sobhanaditya, Chairman, Biosciences, Prof. Siddique, Vice-Chancellor, Osmania University, Prof. Lalji Singh, Director, CCMB, Hyderabad, Dr V.K. Manchanda, President, IANCAS and G.A. Rama Rao, Secretary, IANCAS

exploration' by Mr P.B. Maithani, Additional Director, AMD, Hyderabad created interest among the participants as Mr Maithani cited a few places in Andhra Pradesh which have future prospects for exploration.

A special demonstration experiment on 'DNA-labeling' by Dr N. Krishnamurthy, Jonaki lab, BRIT in CCMB was well appreciated. A visit to Nuclear Fuel Complex, Hyderabad was arranged for the participants and the resource persons. The participants were briefed by Dr P. Balakrishna Prasad, Dy. Director and they were taken through pellet handling facility and few metallurgical processing plants by Mr Sairam. The participants comprehended the safety aspects in handling uranium material while maintaining clean surroundings.

A few posters on FACTS & FIGURES giving comparison of fossil and non-fossil fuels in the areas of energy release and the volume of waste produced and their management drew audience both from the participants and from those who participated in the inauguration and valedictory functions. There were several requests from nearby colleges and schools for demonstration of experiments on radioactivity to be conducted in their

respective institutions and so the resource persons visited seven colleges to conduct a half-day programme with a lecture and an experiment on half-life determination. The invitation was from as far as Mehboobnagar, 110 Km away from the city of Hyderabad which was accepted and the programme was conducted in that college. More than 800 students from several institutions were benefited by this programmes.

The valedictory function was presided over by Prof. P. Mutha Reddy, Registrar, Osmania University and Mr R.N. Jayaraj, Chief Executive, NFC was the Chief Guest. Mr Jayaraj gave away the certificates and donated a set of nuclear counting equipment to Prof. Mutha Reddy and congratulated the participants for completing the training in handling of radioisotopes. He said that the nuclear industry would to play a vital role in meeting future energy demands of the country, considering the alarming situation in terms of greenhouse gases, that have proved to be detrimental to the environment. In his presidential address, Prof. Mutha Reddy said that the feed back from the participants was gratifying and the workshop helped in alleviating the apprehensions of the participants about the safety features of

nuclear energy. Prof. Venkata Ramana Devi, the local coordinator brought out the salient features of the workshop while Dr Rama Rao, Coordinator from IANCAS attended to the suggestions from the participants during the feedback session. Dr K.L. Ramakumar, Vice-President, IANCAS gave an account of the popularity of the association, in propagating the beneficial aspects of radioactivity and the invitations received by IANCAS over the years, for conducting similar workshops in universities.



At the valedictory (L-R): Prof. Ms Ramana Devi, Dr K.L. Ramakumar, Vice-President, IANCAS, Prof. P. Mutha Reddy, Registrar, Osmania University, Mr R.N. Jayaraj, Chief Executive, NFC, and Dr G.A. Rama Rao, IANCAS

## भा.प.अ. केंद्र के वैज्ञानिकों को सम्मान BARC SCIENTISTS HONOURED

पी.सुरेंद्रन, ए.श्रीवास्तवा, ए.के.गुप्ता, जे.आर. नायर, एन.एल. यादव, जे.ए. गोरे, एच. स्पेरो, पी.वी. भागवत, एस. कैलास, नाभिकीय भौतिकी प्रभाग, भाभा परमाणु अनुसंधान केंद्र को नवंबर 1-4, 2006 के दौरान भाभा परमाणु अनुसंधान केंद्र, (BARC) और टाटा इन्सटिट्यूट ऑफ फंडामेंटल रिसर्च (TIFR) में आयोजित बीएआरसी गोल्डन जुबली डीआई-बीआरएनएस इन्डियन पार्टिकल एक्सलेरेटर (InPAC-2006) सभा में एक्सलेरेटर मास स्पेक्ट्रोमीट्री प्रोग्राम एट बीएआरसी-टीआईएफआर पेलेट्रोन एक्सलेरेटर नामक शोध-पत्र के लिए पोस्टर प्रजन्टेशन पुरस्कार से सम्मानित किया गया। यह शोध-पत्र श्री पी.सुरेंद्रन के द्वारा प्रस्तुत किया गया।

A paper entitled "Accelerator Mass Spectrometry programme at BARC – TIFR Pelletron Accelerator" by P. Surendran, A. Shrivastava, A.K. Gupta, J.R. Nair, N.L. Yadav, J.A. Gore, H. Sparrow, P.V. Bhagwat and S. Kailas, Nuclear Physics Division, BARC, was awarded the poster presentation prize at the BARC Golden Jubilee DAE-BRNS Indian Particle Accelerator Conference (InPAC-2006), held at Bhabha Atomic Research Centre (BARC) and Tata Institute of Fundamental Research (TIFR) from 1-4 November 2006. The paper was presented by Mr P. Surendran.



P. Surendran

श्री पी.सुरेंद्रन बीएआरसी-टीआईएफआर पेलेट्रोन एक्सलेरेटर फेसेलिटी में गतिवर्धक भौतिकी वैज्ञानिक हैं इन्डो-सीईआरएन सहयोग के अनुसार आप जिनेवा में एक वर्ष के लिए प्रतिनिधि के रूप में गए थे। आप गतिवर्धक पुंज स्पेक्ट्रमिति एवं गतिवर्धक प्रणाली हेतु किरण गतिविज्ञान में सक्रिय रूप से व्यस्त हैं।

Mr P. Surendran is an accelerator physicist working at BARC-TIFR Pelletron Accelerator Facility. He was on

deputation at CERN, Geneva for one year under an Indo-CERN collaboration. He is actively involved in accelerator mass spectrometry and beam dynamics for accelerator systems.



Ms A. Shrivastava

डॉ श्रीमती ए.श्रीवास्तवा नाभिकीय भौतिकी विज्ञानी, न्युक्लियर भौतिकी प्रभाग में कार्यरत हैं। इन दिनों आप रेडियो ऐक्टिव आयन किरणों से अशक्त नाभिकीय सुविचारित प्रतिक्रिया पर कार्य कर रही हैं। इन्होंने ओरसे, फ्रांस एवं जर्मनी में रेडियो ऐक्टिव अयन किरणों के अनुसंधान क्षेत्र में काम किया है।

Dr Ms. A. Shrivastava is a nuclear physicist working in Nuclear Physics Division. Presently she is working on Nuclear Reaction studies with weakly bound and Radio Active Ion beams and accelerator mass spectrometry. She has worked in the area of research with Radioactive Ion Beams at Orsay, France and GSI, Germany.



A.K. Gupta

डॉ ए.के.गुप्ता एक गतिवर्धक भौतिकी वैज्ञानिक आयन स्रोत एवं आयन किरण तकनीक की विशेषज्ञता प्राप्त कर रहे हैं। बीएआरसी-टीआईएफआर पेलेट्रोन एक्सलेरेटर फेसेलिटी टाटा इन्सटिट्यूट ऑफ फंडामेंटल रिसर्च (TIFR) में परमाणु झुंड भौतिकी, आइसोटोप के दर नाप, एकांतर ईसीआर प्रस्थापन प्रणाली एवं रेडियोधर्मी आयन किरण का विकास आजकल इनकी रुचि के क्षेत्र में शामिल हैं।

Dr A. K. Gupta is an accelerator physicist specializing in ion sources and ion beam technology. His current fields of interest are atomic cluster physics, isotopic ratio

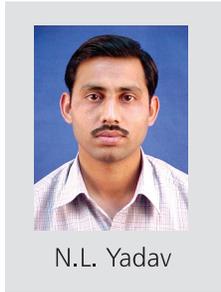
measurements, alternate ECR injector systems and Radioactive Ion Beam development at the BARC-TIFR Pelletron Accelerator Facility.



J.P. Nair

श्री जे. पी. नायर बीएआरसी-टीआईएफआर पेलेट्रोन एक्सलरेटर फेसेलिटी में कार्यरत हैं एवं गतिवर्धक आधारित अनुप्रयोग इनकी रुचि के क्षेत्र में शामिल हैं।

Mr J. P. Nair is working at the BARC-TIFR Pelletron Accelerator Facility and his field of activities include track-etched membrane filters and other accelerator-based applications.



N.L. Yadav

श्री एम.एल.यादव बीएआरसी-टीआईएफआर पेलेट्रोन एक्सलरेटर फेसेलिटी में इलेक्ट्रॉनिकी वर्ग के सहयुक्त सदस्य हैं इन दिनों गतिवर्धक आधारित इलेक्ट्रॉनिकी तथा उपकरण इनकी रुचि के क्षेत्र में शामिल हैं।

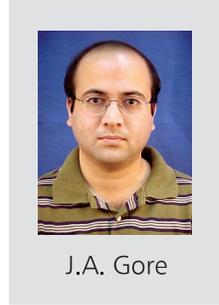
Mr M. L. Yadav is associated with the Electronics group at the BARC-TIFR Pelletron Accelerator Facility. His current field of interest is accelerator-based electronics and instrumentation.



H. Sparrow

श्री हिल्लरी स्पेरो बीएआरसी-टीआईएफआर पेलेट्रोन एक्सलरेटर फेसेलिटी के सहयुक्त सदस्य हैं तथा गतिवर्धक के रख-रखाव एवं गतिवर्धक के उपयोग हेतु एक माध्यम हैं।

Mr Hillary Sparrow is associated with BARC-TIFR Pelletron Accelerator Facility and is instrumental in accelerator maintenance and accelerator-based applications.



J.A. Gore

श्री जे.ए.गोरे बीएआरसी-टीआईएफआर पेलेट्रोन एक्सलरेटर फेसेलिटी इलेक्ट्रॉनिकी वर्ग के सहयुक्त सदस्य हैं। आप सीईआरएन, जिनेवा में एक वर्ष की अवधि के लिए इन्डो- सीईआरएन सहयोग के आधार पर प्रतिनिधि के रूप में थे। आप गतिवर्धक हेतु उच्च करेंट प्रोटॉन गतिवर्धक एवं कंप्यूटर -आधारित

नियंत्रण प्रणाली हेतु किरण नैदानिक उपकरण के विकास में व्यस्त हैं।

Mr J. A. Gore is associated with the Electronics group at the BARC-TIFR Pelletron Accelerator Facility. He was on deputation at CERN, Geneva for one year under an Indo-CERN collaboration. He is presently involved in the development of beam diagnostic devices for high current proton accelerator and computer-based control systems for accelerators.



P.V. Bhagwat

श्री पी.वी.भागवत, अध्यक्ष, पेलेट्रोन एक्सलरेटर फेसेलिटी, एक गतिवर्धक प्रौद्योगिकी वैज्ञानिक हैं। इन दिनों इनकी रुचि के क्षेत्र में गतिवर्धक आधारित जैसा गतिवर्धक पुंज स्पेक्ट्रोमीटरी का अनुप्रयोग, पथ -उत्कीर्ण झिल्ली का उत्पादन शामिल हैं। आप चतुर्ध्रुवी रेडियो आयन की आवृत्ति एवं ईसीआर की

रूपरेखा तथा विकास पर कार्यरत दल का नेतृत्व कर रहे हैं।

Mr P.V. Bhagwat, Head, Pelletron Accelerator Facility, is an accelerator technologist. His current areas of interest are accelerator-based applications like accelerator mass spectrometry, production of track-etched membranes etc. He is heading the team that is working on the design and development of ECR source and heavy ion Radio Frequency Qadrupole.



S. Kailas

डॉ एस. कैलास इन दिनों भाभा परमाणु अनुसंधान केंद्र के नाभिकीय भौतिकी वर्ग के सह निदेशक हैं। आप भारतीय वैज्ञानिक अकादमी के सदस्य हैं। इन दिनों इनकी रुचि के क्षेत्र में नाभिकीय भौतिकी विज्ञान के अन्नवेषित क्षेत्रों का बुनियादी अनुसंधान एवं गतिवर्धक आधारित अनुप्रयोग अर्थात गतिवर्धक चालित उप-समीक्षक प्रणाली, गतिवर्धक सपेक्ट्रोमीटरी, पथ-उत्कीर्ण झिल्ली इत्यादि हैं।

Dr S. Kailas, is currently Associate Director (N), Physics Group, BARC. He is a fellow of the Indian Academy of Science. His current areas of interest are basic research in frontier areas of Nuclear Physics and accelerator-based applications such as accelerator driven sub-critical systems, accelerator mass spectrometry, track-etched membranes etc.



T. S. Rao

डा टी.एस.राव, पानी एवं रसायनिकी प्रभाग, भाभा परमाणु अनुसंधान केंद्र सुविधाएं, कल्पाकम रसायनिकी वर्ग, को अंतर्राष्ट्रीय भारतीय अनुभाग (नैशनल एसोसिएशन फॉर करोज्हेन इंजीनियर्स, यूएसए) एनाएसीई के द्वारा एक्सलन्स इन करोज्हेन साइन्स-2006 पुरस्कार से सम्मानित किया गया। यह पुरस्कार इन्हें नवंबर 30, 2006 को हाइड्रोकार्बन पाइपलाइन्स इन इन्डिया एन्ड टेक्नालोजी मीट 2006 की गोल्डन जुबली समारोह के दौरान प्रदान किया गया था।

Dr T.S. Rao of Water & Steam Chemistry Division, BARC Facilities, Kalpakkam, Chemistry Group, BARC was given the Excellence in Corrosion Science – 2006 award by NACE (National Association for Corrosion Engineers, USA) International India Section. This award was presented during the Golden Jubilee Celebration of Hydrocarbon Pipelines in India and Technology Meet 2006 held at Mumbai on 30th November 2006. Dr Rao received this award in recognition of his meritorious contributions in the held of corrosion science; 1. Microbial corrosion of

titanium, 2. Biofouling and corrosion failure studies of Nuclear Power and Heavy Water Plant cooling systems  
3. Studies on prevention of corrosion by self assembling molecules under Indo-German Program.



V.H. Patankar

डॉ वी.एच.पाटंकर, एवं वी.एम.जोशी, अध्यक्ष इलेक्ट्रॉनिकी प्रभाग, भाभा परमाणु अनुसंधान केंद्र ने हैदराबाद में आयोजित दिसंबर 7, 2006 को नॉन डेस्ट्रक्टिव इवेलिवेशन 2006 पर राष्ट्रीय सम्मेलन के दौरान इन्डियन सोसाइटी फॉर नॉन-डेस्ट्रक्टिव टेस्टिंग (ISNT) के द्वारा राष्ट्रीय श्रेष्ठ पत्रिका शोध पुरस्कार प्राप्त किया।

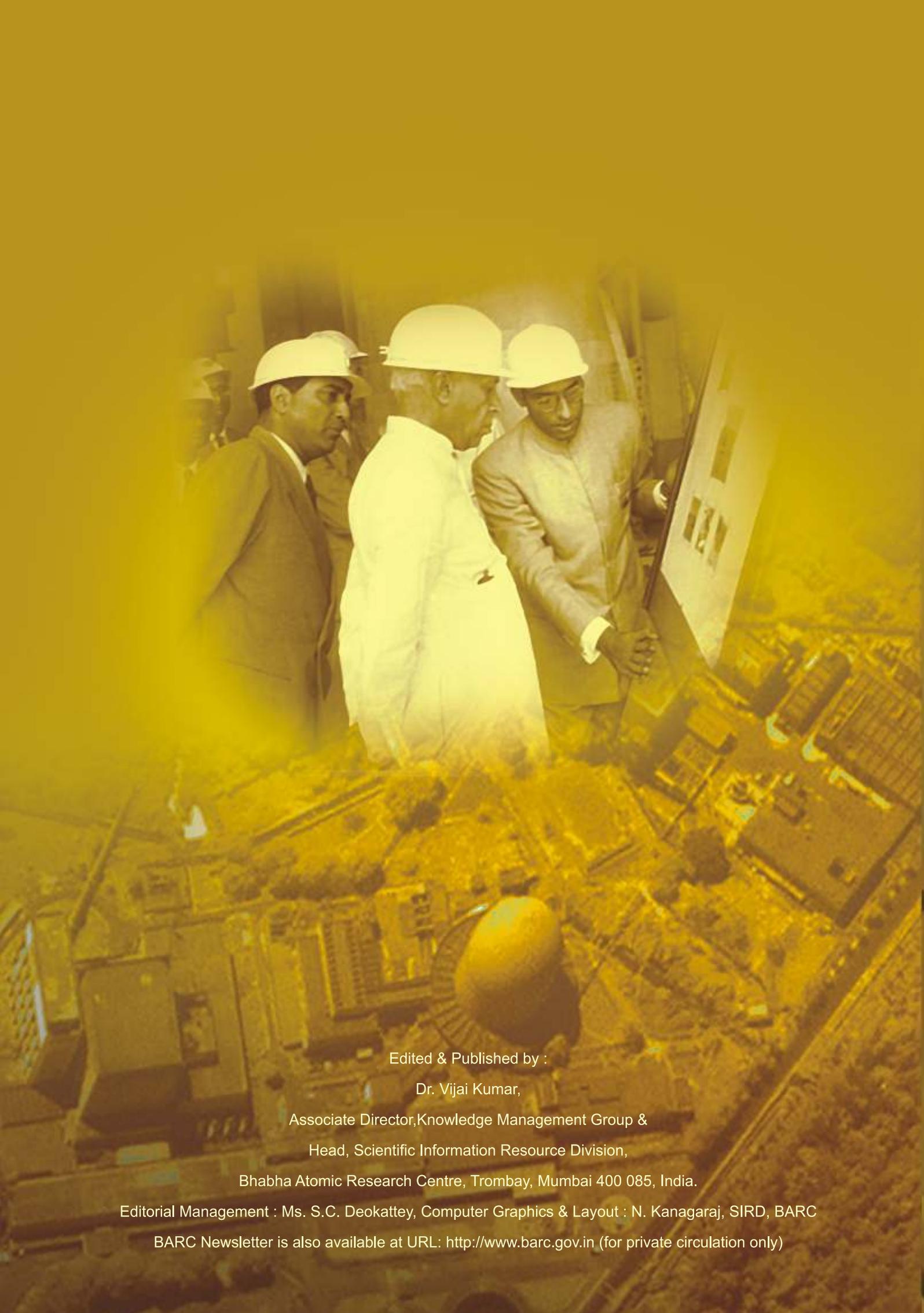


V.M. Joshi

डेवलोपमेंट एन्ड एप्लिकेशन्स ऑफ सी-स्केन अल्ट्रासोनिक फेसिल्टी नामक यह तकनीकी शोध-पत्र भाभा परमाणु अनुसंधान केंद्र के इलेक्ट्रॉनिकी प्रभाग के वैज्ञानिकों तथा वीजेटीआई, मुंबई के एक प्रोफेसर ने संयुक्त लिखा। यह शोध जर्नल फॉर नॉन

डेस्ट्रक्टिव इवेलिवेशन (JNDE) के जून 2005 अंक में प्रकाशित किया गया था। इस शोध में स्वचालित बहुसंचार पराश्रय सी-स्केन प्रतिबिंब प्रणाली (ULTIMA 200M2) एवं मशीनी घटकों के निरीक्षण हेतु इसके अनुप्रयोग का वर्णन है।

Dr V.H. Patankar and Mr V.M. Joshi, Head, Electronics Division, BARC received the National – Best Journal Paper Award 2006, from the Indian Society For Non-Destructive Testing (ISNT), on 7th December, 2006, during the National Conference on Non-destructive Evaluation 2006, held at Hyderabad. A technical paper titled “Development And Applications of C-Scan Ultrasonic Facility” was jointly written by scientists from Electronics Division, BARC, IGCAR and a professor from VJTI, Mumbai. This paper was published in the Journal for Non-destructive Evaluation (JNDE), June 2005 issue. The paper describes the design and development of Automated Multichannel Ultrasonic C-scan Imaging System (ULTIMA 200M2) and its applications for volumetric inspection of machined components.



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