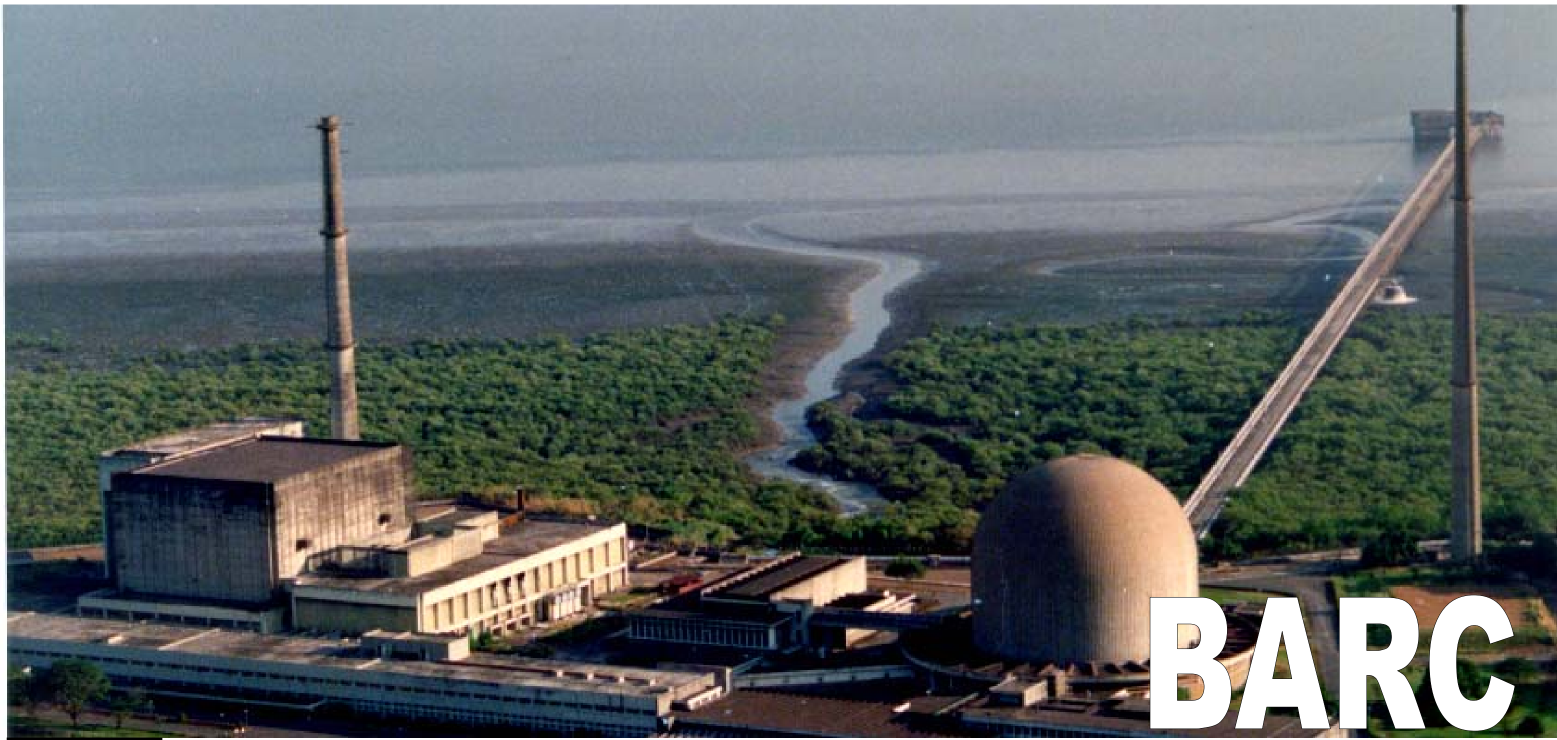

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Contents

CARE AND PRECAUTION REQUIRED FOR "WIRE" & "WIRING" IN REACTOR CONTROL AND INSTRUMENTATION SYSTEMS : EXPERIENCE FROM KAKRAPAR TO KAIGA

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Introduction

Advancement in control and instrumentation with wide induction of microprocessor based C&I systems in a Nuclear Power Plant has neglected the science and art of wires and wiring. A state-of-the-art C&I used in a NPP may be of no use if wire & wiring are not respected. One hears complaints that C&I has spuriously crashed either due to spike in DC power or due to EMI. But, the fact is if due care and respect are not given to wire & wiring, the C&I will then "spuriously" misbehave.

During our development of Kakrapar PDCS (1988) to erase out the earlier method of point-to-point connector wiring by use of the then state-of-the-art Flat Ribbon Cable, the following science was developed. Not only has the method made engineering of a large system (say 100,000 points) possible in 2-3 days (reliably) but also has enabled transmision line with lesser signal distortion, lesser cross-talk and lesser radiation (EMI) compared to the earlier point-to-point wiring. In fact, the state-of-the-art electronics now running C&I of various NPPs and other facilities has this science embedded in its engineering, in the form of FRC & PS structure (not given proper place or forum till date). The fact that all the systems based on standard state-of-the-art EC BUS boards are reliably doing C&I function is due to the care and respect given by the designer for each wire and wiring. In this article, the authors restrict the discussion outside the PCB, Mother Boards and bins and thus discuss only the FRC & PS wire structure, assuming that PCBs and Mother Board layout has the Science of Transmission line embedded into their design.

Nevertheless, high speed electronics introduced by mathematics, communication processors, DSP microprocessors and controllers, etc has made the C&I bins to be distributed electrical entity rather than a lumped entity. With distributed electrical structures, when the dimensions of net are greater than one-sixth of electrical length (ratio of rise time to electrical speed 85ps/inch in FR4), it is advisible to have transmision line approach which is superior to point-to-point approach. A point-to-point wiring has large inductance, and when a gate drives the wire inductance and line capacitor (of 50 pF), the signal bounce rings and gets corrupted. TL approach is superior in mainly three ways, i.e., it has less distortion, less cross talk and less EMI, and hence it is more rugged. In lieu of these good properties, more drive-power is required here due to lower characteristic impedance (80-100 Ω) of distributed TL, than in point-to-point wiring. This point is taken care of by suitable high current drivers employed for these fast computer signals, and to drive it across FRC from bin to bin, super high current drivers are employed in the design. Also, distributed circuit will always ring if unterminated; hence, suitable terminators are provided in the standard EC bus boards and systems.

Due to "taken for granted" approach for wires and using a state-of-the-art fast response, ECPS with load sharing design to power ECL logic of TBC modem often blamed the PS design when the system crashed while communicating. The inspection of these NPP systems reveals that PS wire structures are far removed from the desired scheme to cater for high speed logic and have wide area of loop in the PS wires, thereby inviting the EMI. The point is that attention has to be given to each and every wire to make the system robust in demanding HF current. Hence, complaining that ECPS 5V has large spikes and dips is of no use, unless one improves the PS structure.

Use of FRC not only has made the engineering easy compared to the point-to-point system, but salient truths about science of FRC is mentioned in this article. In NPP system, we have restricted the length of FRC to a maximum of 10 feet and have artistically distributed analog or digital I/O signals as G-S-G-S configurations. This has given improved time front profile and less timing jitters as compared to point-to-point system.

In this article, only FRC related issues and PS structure is discussed. Degradation of rise time due to connector pin, the PCB clock track and other issues related to VIA (PTH) management and signal bounce due to improper termination have not been touched due to lack of space. However, these leftout issues are duly taken care of in EC bus boards and ECPS design and implementation.

In this article, wherever formulae are used, the dimensions are in non-SI units, the reason being the AWG to diameter conversion relation uses FPS system for dimensions (i.e., inches).

AWG = -10-20 log (D) where D is wire dia in "inches". This AWG is followed as standard for resistivity, inductance, etc calculations for wire. Due to this reason, the PCB, connector pitch, etc are expressed in terms of "thou", i.e., thousandth of an inch and connector pitches come as 0.1" grid or 0.05" grid (rarely "mm" is mentioned, except for PCB track width). Therefore, in this article, inch or FPS is followed rather than SI system.

Flat Ribbon Cables (FRC)

We have been using FRC in Reactor Control and Instrumentation System with computer electronics since 1988 (KAPP-PDCS). The use of the same with artistic and scientific geometry with scientific signal distribution has not only increased the signal termination density and distribution capability, but also has made C&I engineering easy. FRC use has made the C&I system better EMI/EMC compliant with proper signal wave front distribution removing timing jitters. For the first time in Nuclear C&I system, FRC was used in Kakrapar PDCS system, after which use of FRC became standard for Nuclear C&I. Even hardwired systems like MIAS and HIU use these FRC schemes. Earlier in Dhruva C&I and Kamini C&I point-to-point connector wiring were employed. Presently, a few Dhruva systems are getting upgraded to FRC scheme.

The original 3M ribbon cables were having multiple conductors bonded together in a flat wide strip in thick extruded grey plastic insulating medium. Later, developments like rainbow cables, resembling individual round wires bonded together, became standard. Now, some ribbon cables support their wires on the surface of a thick plastic insulating strip, mainly used in defence C&I flexible fast logic motherboards and like interfacing standard signals of IDE to high density solid state discs. In the above, each di-electric configuration has different HF frequency properties. Refer Fig. 1, for the three different types of FRC.

observations of the instrument rack reveals that these are prone to EMI and signal distortion. Hence, for those applications too, it is suggested to have FRC schemes.

FRC Signal Propagation, Frequency Response and FRC Length

Rise time $T_{10-90} = (L)^2 / K$

where K=Cable dependent constant in ft^2-GHz, and L= length in feet. This formula is valid for even co-axial cables, twisted pair and ribbon cables. The formula shows that cutting length to one-tenth shortens the rise time by a factor of hundred. Band width is

$|H(f)| = \exp[-0.546 \{ (L)^2 (f)^{1/2} \}] / K$

where $|H(f)|$ =magnitude of frequency response, f = frequency in GHZ, K = Cable dependant constant in ft^2-GHZ, and L= length in feet.

Some variance from this formula exists if the di-electric properties of the insulating medium change. Other variance exists below the skin effect frequency (approx. 100 KHz) for reasonably sized cable. Finally, at the lowest frequency, a cable reverts to RC mode, which introduces unusual phase distortion. RC mode problems normally occur on a very long cable which must be operated below a few KHz.

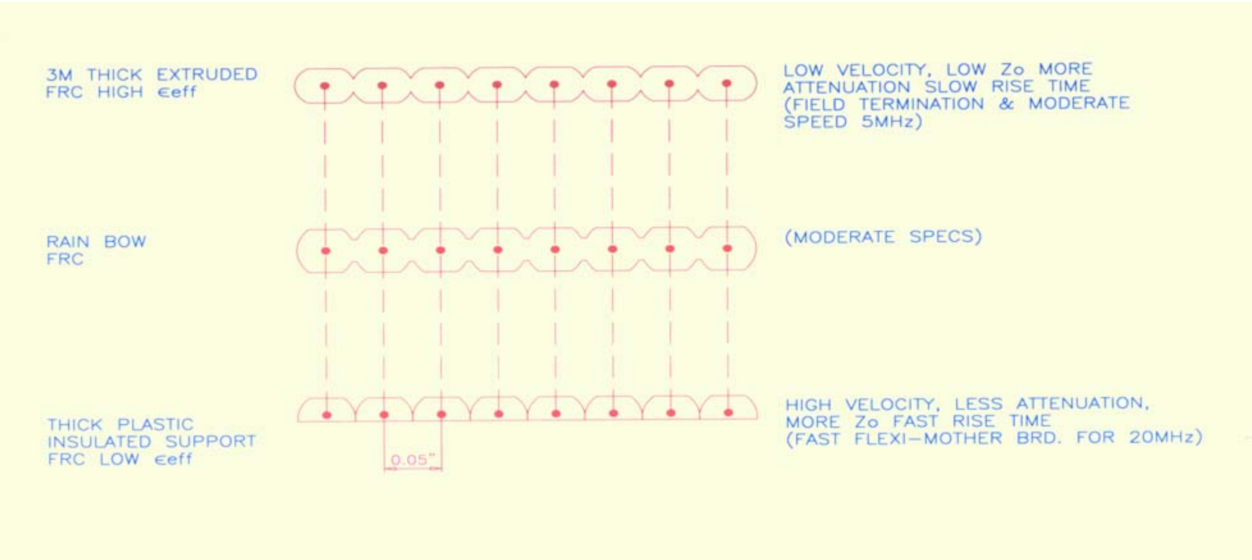

Fig.1 Cross section with relative performance index of three dielectric configurations of flat ribbon cables

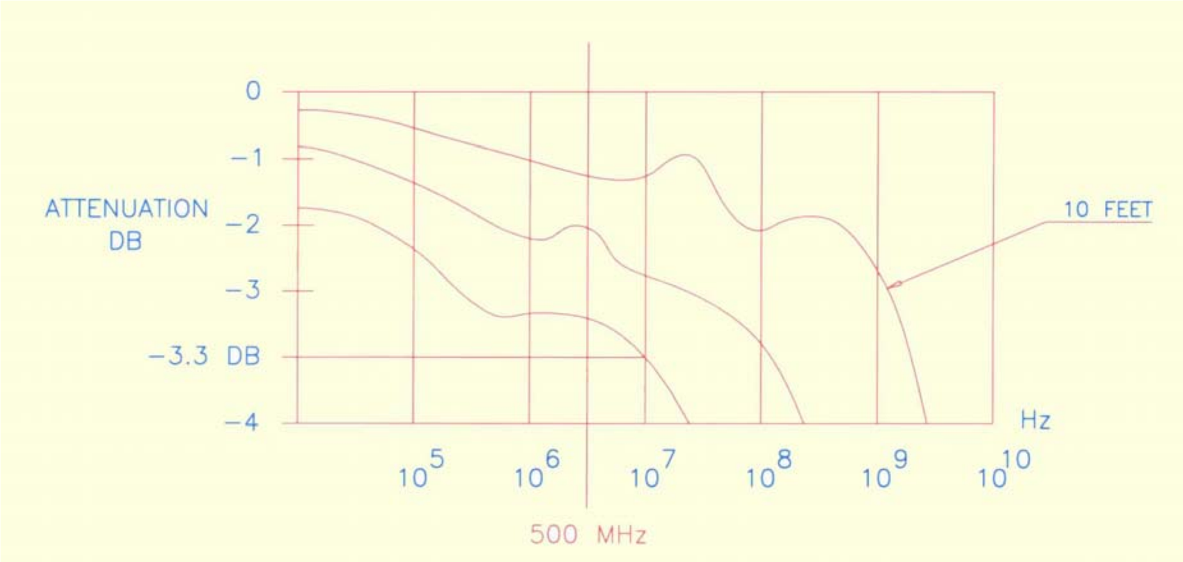

Fig. 2 FRC Freq–response vs Length

At digital frequency, the shape of the frequency response curve is dominated by skin effect.

A RG59U Cable has a lower Ω/ft than AWG30FRC, and hence a higher value of K. So, we get less attenuation per foot on RG59U than on AWG30FRC.

FRC frequency response is simply how well FRC works at short distances. Response off course depends on how the GND is connected. Let us assume G-S-G-S connection, which is the case for all systems made on standard EC-Bus boards, gives characteristic Zo as 80 to 100Ω (depending on di-electric).

In Fig. 2, over a span of 10 feet, we can expect an attenuation of less than 3.3 DB upto about 500 MHz. The effective BW varies with inverse square of distance. For connections shorter than 10 feet, FRC performance is terrific. At distance greater than 10 feet, FRC cable deteriorates markedly. At 100 feet, 3.3 DB attenuation point occurs at 5 MHz, yielding rise time of 100 nS. All C&I systems based on EC-Bus follow this length criteria.

Effect of Surround Di-Electric in FRC

The cable dielectric configurations impacts the performance of FRC in two ways. It controls the signal propagation velocity and it controls attenuation. Cable having dielectric material completely surrounding the wire (Ref 3M FRC diagram, Fig.1) exhibit a higher effective permeability (E_{eff}), and thus lower is the overall speed. Cable supporting the wire on the plastic sheet carries most of the electric field in air and therefore has lower effective permeability and higher speeds. (Fig. 1)

Attenuation depends on the ratio of series resistances to the cable impedance. At high frequency, the skin effect causes resistance to rise with square root of frequency. The dielectric configuration influences attenuation by changing the cable characteristic Zo. Cable having surround dielectric has higher E_{eff}, thus lower Zo and more attenuation.

Rise Time Distortion FRC

As earlier shown, the cable rise time is proportional to square of its length. The cable waveform is a result of its unique $(f)^{-½}$ freq. response. The middle section of the pulse rises quickly, but is preceeded and followed by long slow moving tails. This is common to all conductive type cables but not to optical cables. These cable waveforms are not like Gaussian rising waveforms that comes from logic gates or complex systems.

At very long lengths, when cable reverts to an RC mode, the response becomes more asymmetric. The precursor shrinks but the final slowly rising tail gets worse. These long tails introduce significant intersymbol interferences in long distance transmission systems.

For digital applications, the system clock should be much slower than 10-90% t_r of the cable to avoid overlap. Ref Fig.3 for rise time distortion in FRC.

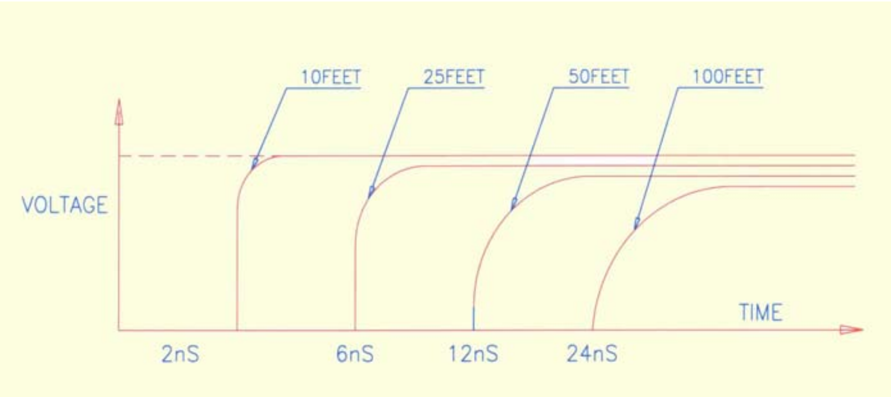

Fig. 3 Rise time distortion vs Distance for cable

Cross Talk in FRC

(i) Magnetic field intensity, as a function of distance from each wire, varies as 1/R.

(ii) Magnetic field from signal wire and return wire path partially cancel. The overall magnetic field profile is thus $1/R^2$, which is a derivative of 1/R. The integrated flux over any small area remote from A&B will vary as $1/R^2$.

(iii) The partial cancellation of field from signal and return wires is proportional to the separation between them (Fig 4).

(iv) Total flux captured between the two receiving wires is proportional to the separation between them (Fig. 4).

(v) In G-S-G-S configuration (followed in standard EC bus based designs), the reverse cross talk coefficient between nearest neighbour is 2.5%.

(vi) In a twisted cable, the rising edge spreads out over N precessions of twist cycle, and so we can expect coupling to be about 1/N of the amount in ordinary FRC.

(vii) When routing the FRC, always use cable spacers to keep the cables separated.

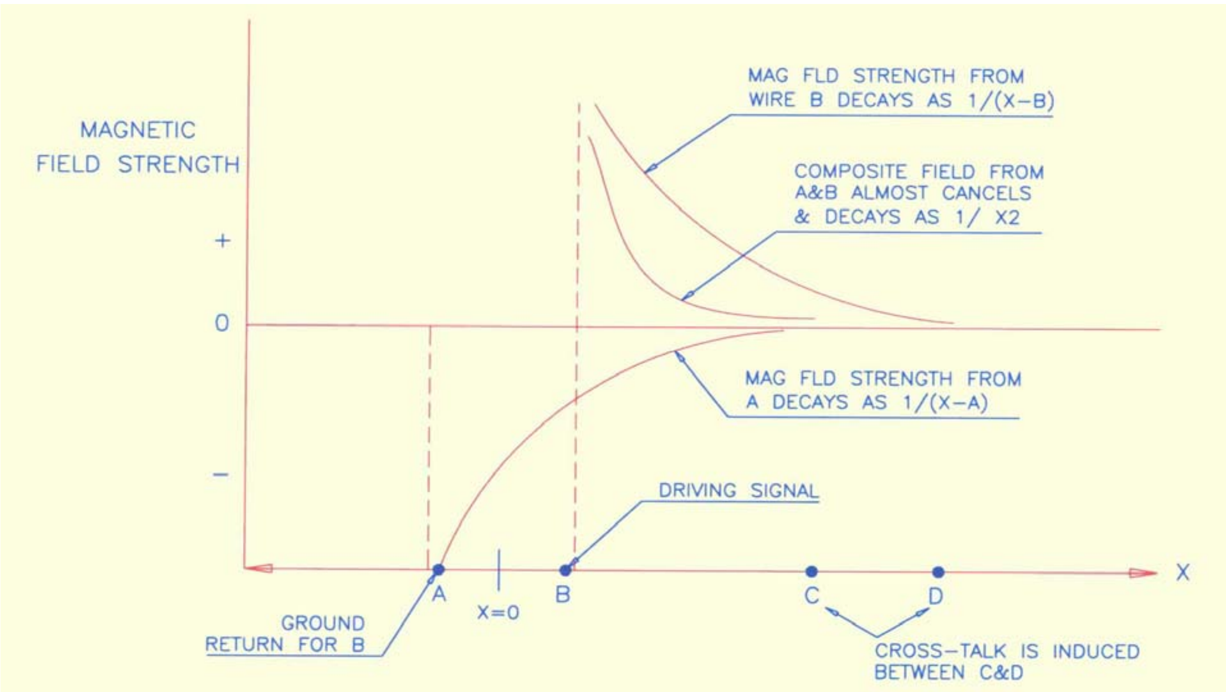

Fig. 4 Cross talk in FRC due to magnetic coupling

FRC EMI

FRC suffer EMI problems when routed between the cabinets. Flat foil wraps provide low inductance path for signal currents. Spirals should make firm contacts, else the return currents would be spiralling round the signal wires to source. Flat shield on one side of FRC is a good EMI absorber. A flat copper braid, bounded to one side of FRC, gives several advantages. First, the proximity of the copper braids acts like GND plane, reducing cross talks between individual wires in the cables. The bonded copper braid is more uniform than foil wrap and offers better transmission line characteristics. Also, the copper braid provides a low inductance path for returning signal currents. The braid has drain wire to be connected to the ground. Manufacturers can scrunch or fold a FRC into a round shielded jacket. In this form, the shielded FRC looks like a regular shielded multiwire cable.

Fig. 5 will give pros and cons of using this scheme for LF analog system vis-à-vis HF digital system. As marked, current loop A is large enough to exceed FCC/VDE EMC/EMI limits. Drain wire works well in analog and at LF. Drain wire makes poor ground for a HF digital circuits. The current loop A would radiate, and hence we insist on a connector with a metal exterior shell. The foil or braid sheet should clamp directly inside the metal shell, leaving no wiring exposed. The metal shell should mate using a flat wide low inductance contact to metal exterior of the product chasis (instrument rack).

Power Supply Wires

Working together, the power supply, its wiring the big bypass capacitors and the small by-pass array of capacitors provide a low impedance power source for every logic device across the entire frequency range. The entire “wiring” system may be termed as multilayered power distribution system.

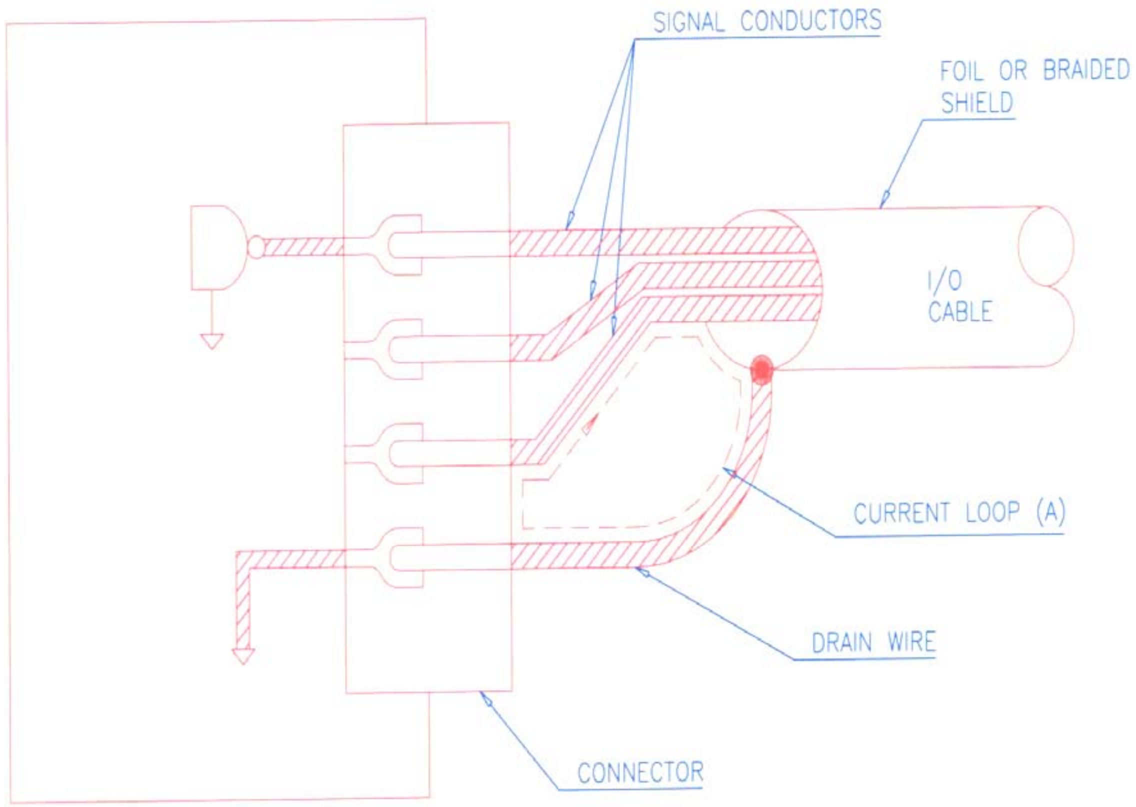

Fig.5 Shilded FRC

The distributed wiring needs a scientific thought. On inspecting all the C&I systems racks in NPCIL and in compact reactor C&I where micro computers and digital logic are used, we found they are not EMI/EMC resistant. Advancement in Control & Instrumentation should also take care in this side as this unattended part remains weak link in the entire C&I system and we complain about spurious computer C&I stoppages. Rapidly changing currents, acting across the inductance of power distribution wiring, induce voltage shifts between the supply and the logic it feeds. These voltage shifts are more sudden and far larger than the shifts introduced by wiring resistances. Unfortunately, sense wire circuit cannot respond quickly enough to correct the spikes introduced by wiring inductances.

Inductance Filtering of Wires

A simple circuit theory solves the problem of spikes introduced by uncared large inductances of the power supply wires. Fig. 6 shows gate. A driving a capacitive load $C_L = 50_pF$ when on high logic. Rise time of gate A T_{10-90} is 5nS. The KCL gives $I(t) = \frac{v(t)}{R} + C\frac{dv(t)}{dt}$. Differentiatating this gives rate of change of current as

$$\frac{dI(t)}{dt} = \frac{1}{R}\frac{dv(t)}{dt} + C\frac{d^2v(t)}{dt^2},$$

$$\text{Max } \frac{dI}{dt} = \frac{1.52\Delta V}{(T_{10-90})^2} C_L = 1.5x10^7 A/S$$

$\Delta V = 5V$, $T_{10\text{-}90} = 5nS$, $C_L = 50\ _pF$

L = 10.16 x ln [2H/D] = 164n H

X = 10 inch, H = 0.1 inch, D= 0.04 inch (AWG 18)

From above, spike voltage

$$V = L\frac{dI}{dt} = (1.52 \times 10^7)(164 \times 10^{-9}) = 2.5V$$

Here, actually the wiring inductance is so large that when gate A tries to drive HI, the PS input at the card will drop nearly to ZERO; slowly rising as C_L is charged through the inductance of wire.

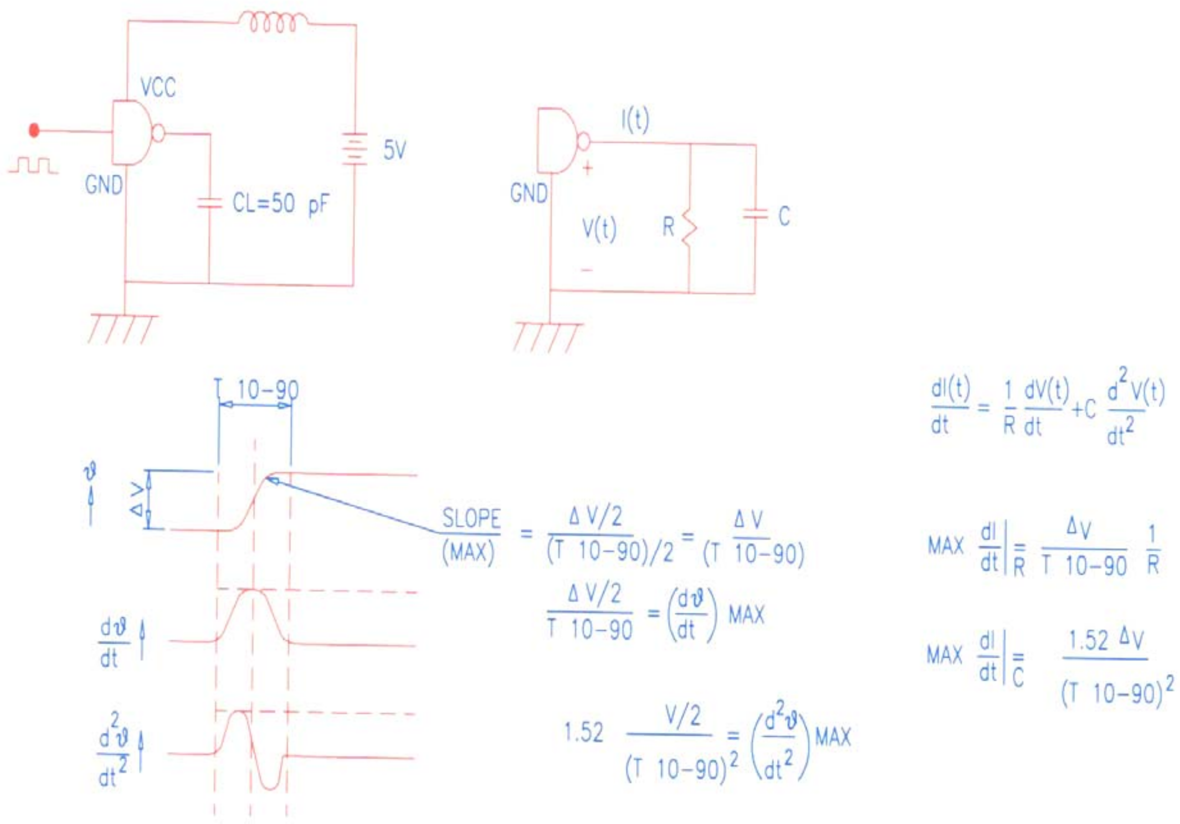

Fig.6 Graphical derivation of inductance filtering of PS wire

When the PS droops to ZERO, gate A may no longer function or it may break into oscillations. What to do? Here use (C_2) a by-pass of lower impedance instead PS wiring. But these by-passes are not of ideal nature always. So obvious way is to reduce L of PS wiring.

Shape & Structure of PS Wires

Since inductance is a logarithmic function of diameter of PS wires (164nH for AWG 18, 0.04 inch dia wire), it is almost impossible to reduce wiring inductance by simply using bigger wires. L=10.16 X Ln [2H/D], X= length in inch, H= Avg separation between +ve & -ve wires in inch, D is wire dia (AWG 18 is 0.04 inch), L= Inductance in nH.

Here, wide flat parallel structure should work better as distribution wiring than implemented round wires. The lowest inductance distribution wiring should use multiple flat ribbons, with power and ground on alternate layers (as opposed to present practice of using multiple round bunches separated widely by different routes). The above trick will not only reduce wiring inductances substantially but also would help to have better EMI/EMC compatibility, due to reduced area and inductance of PS wires. The effective inductance of flat wide structure in nH is L=31.9 { XH/W(N-1) } where X = Length of ribbon in inches, H = separation between ribbon plates in inches, W = Width of ribbon in inches, N = Number of plates (count 2 for single power and ground, 3 for double ground and one conductor, etc).

EMI and Cross Talk in Point-to-Point Wiring and Less in FRC and Proposed PS Structure

Large current loops like those found in wire wrap products (Kamini C&I, Dhruva C&I, Compact Reactor C&I) should raise big red EMI flag. Large currents generate transient fields. Transmision lines dramatically reduce EMI, as in FRC and proposed PS wiring structure. They accomplish this by constraining the flow of return currents.

With ordinary wiring, currents from logic drivers flow out on signal wire and return “some how” along the power wiring. The separation between these two paths or total loop area between them is large and hence they radiate and is source of cross talk.

This issue was tackled in 1988 by removing point-to-point wiring all together by use of FRC and cared PS wiring. Electrically, a point-to-point wiring has large inductance when working into heavy loads (capacitive), makes high “Q” circuit, and hence signals bounce and deteriorate.

Conclusion

A salient point may be put to conclude this: “A wire which is a short circuit for LF signal may be an open circuit for HF”. The PCB, mother board and design may be robustly made, but “spurious” stoppage is observed in NPP C&I. Do not always blame the EC Bus board design or ECPS, but have a look at basic WIRES. Enquire if the PS wiring as implemented in NPP takes care of high speed design. Find out whether spacers are essential for FRC separation, or whether we need to braid the FRC for EMI protection ?, etc. Hence, in order to elevate plant availability due to state- of-the-art high speed C&I, look at the basic WIRES & RESPECT them; the answer may as well be there, instead of blaming Indigenous EC bus board design & ECPS. The compact reactor C&I wiring inspection does raise EMI red flag, hence some technique ought to be sought there. Here, deviation from FRC to point-to-point I/O wiring was done without G-S-G-S concept; perhaps signal profiling there will be aberrated and will not be so EMI/EMC friendly. Hence, do give weightage to each and every wire & wiring, they are not trivial, but as important as state-of-the-art C&I. Change in mindset of using only ROUND wire in C&I is too required to elevate plant C&I availability with state-of-the-art computer control systems.

IN-CELL AUTOMATION: DEVELOPMENT OF REMOTELY OPERATED AUTOMATED IN-CELL GADGETS FOR RADIOISOTOPE PROCESSING

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Introduction

Radioisotope production, processing and supply is an important non-power application of nuclear energy and is being carried out by the Department of Atomic Energy for the past four decades.

Tera Becquerel quantities of a number of radioisotopes such as ^{131}I, ^{99}Mo, ^{32}P, ^{153}Sm, ^{51}Cr, ^{82}Br, ^{203}Hg, ^{140}La, ^{46}Sc, etc. are produced in various radiochemical forms and regularly supplied through Board of Radiation & Isotope Technology (BRIT) for applications in medicine, industry, biology, agriculture and research & development activities. These radioisotopes are produced by neutron activation of suitable target materials in our reactors, Cirus and Dhruva, and are processed in the extensive radiochemical facilities at Radiopharmaceuticals Division, BARC.

The irradiated targets from the reactor are safely transported to processing laboratories and processed further by a series of radiochemical operations such as dissolution, precipitation, distillation, solvent extraction, ion exchange separation, etc.,for conversion of the radioisotope into a desired, radiochemically pure form before it is dispatched to users for further applications. Due to the high radiation field associated with these operations, all the manipulations are carried out in specially designed, suitably lead shielded SS or MS processing plants.

This article describes some of our efforts in the development, fabrication, testing and installation of few of the remotely operated automated in-cell gadgets for use in radioisotope processing plants for the first time.

Radiochemical Operations : Current Status

The radioisotope processing facilities at Trombay built during the mid sixties consist of a series of MS or SS glove boxes suitably shielded with 100 mm lead wall structure and are fitted with remote manual can cutters, remote tong units, manual pantographic arrangement for dispensing and manual crimping of glass vials containing dispensed radioactive solutions. The aluminium can with irradiated target containing the radioisotope is cut open using a cutter that is manually operated from outside the cell. The target with the radioisotope is transferred to a reaction vessel for further radiochemical operations. After final purification, the radiochemical is dispensed into individual glass vials using the pantographic unit fitted with a glass pipette which is operated from outside. Finally, the vial is fitted with a rubber closure and then secured with an aluminium cap crimped manually in the transfer port of the cell.

In a typical batch processing operation, several 100 Giga Becquerels (>3-30Ci) of radiochemicals with associated beta and gamma emissions are handled. The radiation field during the above operations is of the order of 0.2-0.5 Gy/hour. As a result, during crimping operations wherein a crimping tool with short handle are used, the operating personnel may be exposed to high extremity doses and sometimes whole body exposures. In order to limit the man-rem exposure to any single operator, the operations are usually carried out by a number of personnel on rotation.

In-cell Automation: The Need and Bottle Necks

Over the years, the demand for some of the radioisotopes both for medical and industrial applications has been steadily increasing. In the field of nuclear medicine, the therapeutic applications have been growing, leading to an increase in the number of radionuclides with potential use. Several radionuclides that emit particulate radiations, most often β^-, are used world wide for treatment, particularly of cancer. In our own country, with the emerging trends in the radionuclide therapy, Tera Becquerel quantities of these radionuclides will be required in very high radiochemical and radionuclidic purity for the treatment of burgeoning cancer population. Moreover, international and national regulations on radiation protection have considerably brought down the limits of radiation exposures to occupational workers. In order to reduce the radiation exposure in accordance with the ALARA principle and to optimize the man power available for radiochemical operations, it has become necessary to introduce automated in-cell gadgets to the maximum extent possible in the production and processing of radioisotopes. Development, testing and installation of these in-cell gadgets have become an urgent need. It is also necessary to build new radioisotope processing facilities incorporating several remote handling process gadgets with the state-of-the-art automation in the existing laboratories to sustain the current operations and to meet the future demands for radioisotopes in the country.

Some of the important operations carried out during radiochemical processing of radioisotope production are: cutting of aluminium can containing the irradiated target, transfer of target to the reaction vessel, handling and dispensing of radioactive liquids, capping and decapping of vials containing radioactive solutions, loading of consignment vials in suitable lead containers for packing and transportation. Majority of in-cell gadgets for such operations are custom made and are not available commercially and indigenously. Commercially available vial sealing equipment mainly used in pharmaceutical industry is bulky and cannot be transported through the access openings of the cells and accommodated within the radioisotope processing plants. Moreover, these units are designed for high throughputs which are difficult to maintain and repair remotely within the cell. The limitations such as small cell size, limited access to the cell and the need to maneuver within the cell with the help of remotely operated tongs, call for a rugged and reliable equipment/ gadgets that are custom designed and built so that they can be transported into the cell, retrofitted in the existing layout and maintained within the cell.

Features of Custom Designed In-cell Gadgets

The reliability of any in-cell equipment has to be very high as it can not be directly accessed by human hands. Inoperative equipment due to failure reduces the capacity of the cell and leads to inconvenience to the operator while handling. A simple mechanism with less components, providing actuators only for the essential operations leaving simple handling to the tongs, time based sequential operation in place of proximity sensors are some of the important features that are built into the design of these gadgets to improve the reliability.

Pneumatic actuator is used in these in-cell gadgets as it is simple, safe, has high power-to-weight ratio, capable of direct delivery of linear motion, compact, fast and easy to control. The cell is maintained at a negative pressure with respect to the atmosphere outside to prevent any leakage of radioactivity. Hence, the compressed air lines and cables from the in-cell equipment should be sealed for leak tightness. The compressed air lines are taken out of the cell through the sleeves with adequate gland packing for leak tightness. Since the radiation levels are high, the solenoid valves are kept outside the cell for easy repair and replacement. The exhaust air from the valves is collected and let out into the fume hood to maintain the negative pressure inside the cell. The equipment designed is a low cost unit so that it can be replaced in case of any malfunction with minimum downtime of the plant, instead of attempting troubleshooting and repair after decontamination procedure which is normally not practicable.

Remotely Operated Automated Irradiated Target Can Opener

The target material for radioisotope production is placed in a standard aluminium can and the lid is cold pressed over the can for leak proof sealing. The size of the can after sealing is 22 mm in dia, 46 mm in length. After irradiation of the target in the reactor, the seal is to be opened to retrieve the radioactive target material for further processing. Conventionally, this operation is done manually by a teleoperated tool. The successful opening depends on the skill of the operator as the tool engages partly on the can cover and the tool lever rests on the top surface to support the reaction load. Any error in handling will lead to flying of the can from the holder and spread of active powder inside the cell which is difficult to retrieve and clean. Moreover, there is some hardening of the aluminium can after irradiation, making manual opening operation physically strenuous. Considering the demanding requirement, a simple, remotely operated automated can opener using compressed air with hand lever operated valves has been developed using pneumatics.

The can opener's tool developed is semicircular in shape and is mounted on a lever. The lever pivoted on the piston rod rests on a platform by an offset support. The can is inserted in the holder by the tong and pushed towards the tool by a pneumatic cylinder. The moving can lifts the tool and gets engaged with the tool profile. The tool is pushed down by another cylinder to open the can by breaking the continuity of the seal. The tool is then lifted and the can is pulled out for further handling. Any such operation has to result in the opening of the seal without any chip falling into the can and contaminating the target, which would complicate the radiochemical operations. Utmost care is taken to avoid any spillage of target material during the entire operation. As the tool is pivoted on the piston rod, the arc movement of the tool while pushing down reduces the distance from the can. This leads to sudden jerk and spillage, if the can transfer cylinder is continuously pressurized against the tool. To overcome this difficulty, a three-position valve, all ports exhausted in mid position, is used. After the can engages with the tool, the valve is brought to the mid position to allow the can holder to move freely closer to the tool as the opening operation continues. The above sequences of operations are generated by the hand lever operated valves mounted outside the cell.

The overall size of the unit is maintained at 100 mm (width) x 200 mm (height) x 400 mm (length) so that it can be taken into the cell through the transfer port. This is a major achievement as the unit can be placed on the trolley and moved to position inside cell for proper alignment and subsequent use. One such unit was developed and, after elaborate testing with dummy irradiation cans, was installed in ^{99}Mo processing plant. This is regularly being used for cutting cans containing the irradiated molybdenum oxide target for ^{99}Mo processing. Figure 1 shows the remotely operated Aluminium Can cutting unit.

Based on the feedback received from the operating personnel, the design of the can cutting unit was suitably modified so that the sequence of operation is generated by a microcontroller for adoption in subsequent fabricated units.

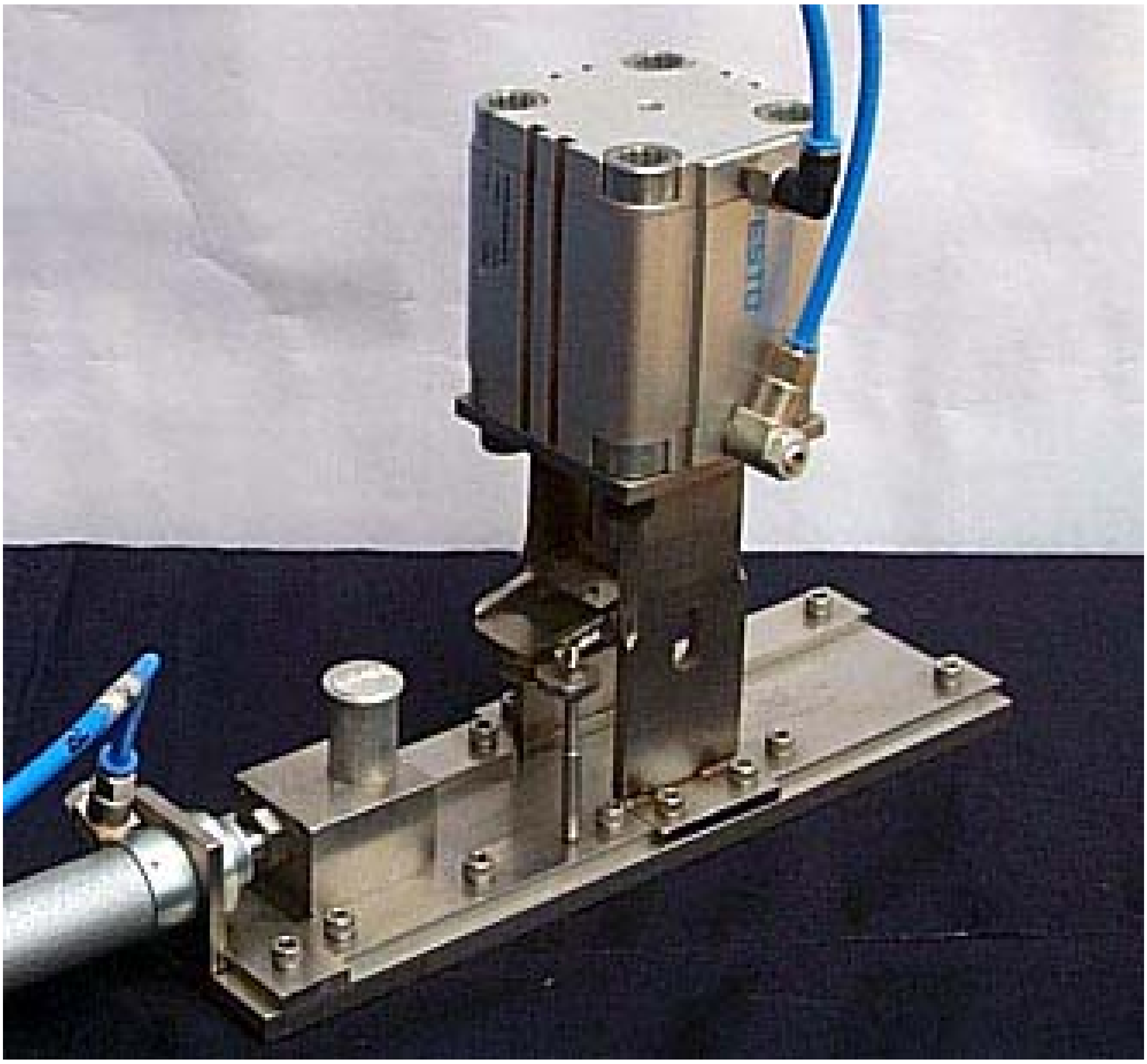


Fig.1 Remotely operated automated irradiated Aluminium Can cutting unit.

Remotely Operated Automated Vial Crimping Unit

The radiochemicals dispensed into glass vials are to be secured leak tight with rubber closures and aluminium caps that are crimped before they are taken out for packing and dispatch to customers. In the automated vial crimping unit developed, a standard crimping tool is fitted and is operated by compressed air. The tool which is normally held above is brought down by a pneumatic cylinder and another cylinder operates the crimping tool. A simple microcontroller generates the sequence of operations. Considering the variation in the air pressure, the delay between the operations is slightly increased to ensure the completion of the previous activity. The increase in cycle time is acceptable for the anticipated low volume crimping operations of 10-30 vials per batch.

The glass vials, rubber bungs and aluminium caps required are loaded on to the trolley in the transfer port and taken into the cell. To start with, one vial is lifted by the tong and kept in the plugging station receptacle in front of capping station. The receptacle holds the vial firmly during the plugging operation. After dispensing of the radiochemical, the rubber closure and the aluminium cap are positioned on the vial by the tong, lifted and pushed through the guide way under the sealing tool. The sealing is done by operating the controller kept outside the cell. The cycle time for capping operation is ~ 4 sec. The sealed vial is taken outside the cell and loaded into the lead pot for further transportation. The overall size of the crimping unit is maintained at 200 mm (width) x 250 mm (height) x 300 mm (length) so that it can be taken through the transfer port. Separate units are made for crimping of 10/15ml and 100ml vials. One automated crimping unit for crimping 100 ml vials has been installed in ^{99}Mo processing plant and is in operation since October, 2003. More than 300 ^{99}Mo consignments have been capped with this unit satisfactorily inside the plant without any apprehension by the personnel and with negligible radiation exposures to the personnel during these operations. A similar unit for crimping 10ml vials has also been developed and is in operation in ^{131}I processing plant for the past six months and about 600 consignments have been capped using this unit. This is a major achievement as it has improved the safety of the operation since crimping is now done inside the cell and has instilled confidence in the personnel involved in these operations. The photograph of a 10ml vial crimping unit is given in Figure 2.

Fig. 2 10ml vial crimping unit installed in ^{131}I processing plant.

The design and development of an integrated assembly unit capable of dispensing radioactive consignments into glass vials using a remotely operated peristaltic pump, sealing the vials using combination seal where the rubber closure and aluminium cap is made as one single unit and provision for easy replacement of crimping tool head remotely using tong in case of failure of crimping tool head are under consideration.

Reduction in Man-rem Expenditure vis-a-vis the Use of Remote Crimping Unit

The radiation dose received by the operating personnel during crimping of ^{99}Mo consignments in a typical ^{99}Mo processing batch (^{99}Mo activity: ~1000GBq/batch) both to the hands and chest were measured by using direct reading dosimeters. The radiation field was also recorded and compared to that prevailing when the consignment vials were crimped manually using a hand held crimping tool in the transfer port. The results are given in Table-1. It is seen that qualitatively there is a good agreement between the radiation field and the dose received by the personnel. Considerable reduction in the man-rem expenditure was achieved by carrying out the crimping operations inside the shielded plant using the automated crimping unit developed as compared to that when the operations are carried out manually in the transfer port. Since these operations are carried out every week through out the year in addition to processing and dispensing of several other radiochemicals on routine basis, the cumulative reduction in man-rem expenditure in a single operation as above is considerable and goes a long way in achieving the ALARA requirements.

Table1 : Comparison of radiation dose received during crimping operations

Parameter measured	By manual crimping	By remote crimping unit	By manual crimping	By remote crimping unit
	Operator-1		Operator -2	
Radiation field[a]	0.12Gy/h	~ 0.02 mGy/h	0.11Gy/h	~0.02 mGy/h
Dose Equivalent [b] (µSv)	Wrist /Chest	Chest	Wrist /Chest	Chest
	57.0/ 7.0	1	50.0/ 6.0	1

Scope of In-cell Automation: Future Plans

Development of in-cell / process gadgets and their adoption for radioisotope processing has a long way to go considering that modern radioisotope processing plants elsewhere in the world use state-of-the-art automation using manipulators and robots. Most of the radiochemical operations such as target can cutting, target transfer, radioactive liquid handling/transferring, dispensing, crimping and transportation have to be serially carried out using automated systems. The envisaged increase in demand for radioisotope products in the country in the coming years would in turn require that the automation should be at par with the radioisotope producers world over. With the complexity of the operations involved, each automation demands fabrication of prototypes and demonstration of their operations before being incorporated in regular plant operations. An integrated concept involving automation of majority of radiochemical operations using a state-of-the-art robotic assembly is the requirement of future radiochemical processing plants. This demands the working of in-house/outside engineers' in-close association with the personnel engaged in radiochemical operations.

Conclusion

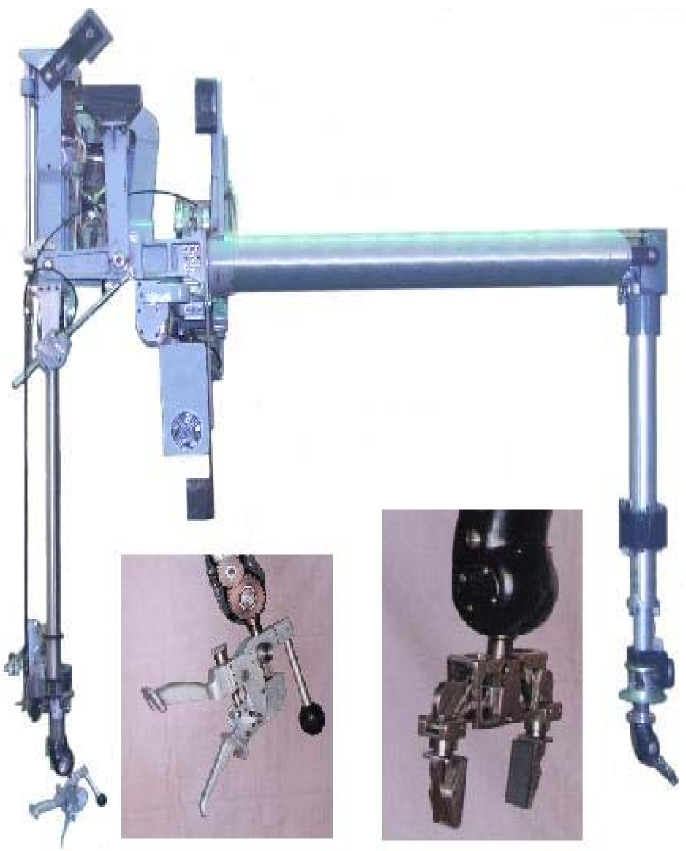
The need for the development of in-cell/process gadgets for radioisotope processing and introduction of automation has been felt since long. However, a small beginning has been made now by the development, demonstration and installation of few of the in-cell gadgets such as remotely operated automated irradiated target can opener and automated vial crimping device using pneumatic systems. Deployment of the above units in regular radiochemical operations has been carried out successfully and has resulted in considerable savings in man-rem expenditure. Based on the above experience, it is planned to develop comprehensive automation systems based on electrical drives using state-of-the-art robots in the years to come.

HMT HANDS OVER RUGGED DUTY MASTER SLAVE MANIPULATOR TO BARC

Hindustan Machine Tools Limited, Bangalore, has completed the fabrication and assembly of 20 pairs of Rugged Duty Master Slave Manipulators (RDMs) based on the design and drawings supplied by Division of Remote Handling and Robotics (DRHR), BARC, Mumbai.

On January 20, 2005, Mr M. S. Zahed, Chairman & Managing Director of HMT Limited, handed over the 20th pair of RDM to Dr Anil Kakodkar, Chairman, AEC, at HMT Limited, Bangalore. The function was attended by Dr S. Banerjee, Director, BARC, Mr G. Govindarajan, Director, Automation & Manufacturing Group and Electronics & Instrumentation Group, BARC, Mr Manjit Singh, Head, Division for Remote Handling & Robotics, BARC, Mr K. C. Sahoo, Head, Post Irradiation Examination Division, BARC, Mr K. Jayarajan, Head, Tele-manipulator Section and Mr G. V. Ramesh, Head, QA-NPCIL, Bangalore.

Mr M.S. Zahed, Chairman and Managing Director, HMT Ltd., Bangalore, handing over the last pair of RDM to Dr Anil Kakodkar, Chairman, Atomic Energy Commission and Secretary, Department of Atomic Energy, Government of India. Dr S. Banerjee, Director, BARC, looks on.



Rugged duty master slave manipulator

The manufacture of RDM was based on a Memorandum of Understanding (MoU) signed between BARC and HMT. The manipulators will be used in the new hot-cells of PIED, BARC, for Post Irradiation Examination. Quality Assurance of the manipulators was performed by NPCIL QS.

BARC has attained self sufficiency and maturity in Mechanical Manipulator (MSM) technologies. Various models of MSMs such as Articulated Manipulator, Model-8 Manipulator, Extended Reach Manipulator and Sealed Type Three-Piece Manipulator developed by BARC are available in various capacities and ranges to suit the hot-cell.

Handling capacity of RDM manufactured at HMT is very high (45 kg), which is close to that of human being. Also, the RDM has large volume coverage of 20 m^3. Although the range of human arm is about 1 m^3, the larger range of the manipulator is utilized by augmenting human arm motion with electrical motions.

RDM consists of the assembly of a large number of miniature, intricate and precise parts. Mechanical power transmission from one side of hot-cell wall to the other through various moving joints is a challenging task in MSM design. Design and manufacture of a reliable system with hundreds of moving parts, keeping it light weight, with low friction and low backlash is also a difficult task. Materials and components used in MSMs are of high strength and radiation resistant.

RDMs supplied by DRHR are being used for heavy duty applications in fuel reprocessing, waste management, radioisotope production and post irradiation examination. Also, BARC has supplied RDMs to INS Tunir, Indian Navy, for remote rocket fuelling.

Experience of BARC in the design of remote handling tools, precision fabrication capabilities of Hindustan Machine Tools Limited, combined with rigorous quality assurance by NPCIL QS, has resulted into a world class product.

BARC TRANSFERS TECHNOLOGY OF "LOW BACKGROUND GAS FLOW BETA COUNTER"

The technology of "Low Background Gas Flow Beta Counter" developed by Radiation Safety Systems Division (RSSD) has been transferred to M/s. Nucleonix Systems Pvt. Ltd., Hyderabad, on January 18, 2005.

Photograph after signing the technology transfer agreement. Seen from left to right are : Mr B.K. Pathak, Head, TTS, TT&CD, BARC, Dr R.R. Puri, HRDD, BARC, Mr A.M.Patankar, Head, TT&CD, BARC, Mr J. N. Reddy, MD, M/s Nucleonix Systems Pvt. Ltd., Hyderabad, Dr R.B. Grover, Director, Knowledge Management Group, BARC, Dr D. N. Sharma, Head, RSSD, BARC, Mr D.A.R. Babu, RSSD, BARC, Ms K. Narayani, RSSD, BARC, Ms Soniya S. Murudkar, TT&CD, BARC.

Counting of samples having very low specific beta activity becomes difficult with conventional G.M. counters having high background and low efficiency. A gas flow type beta counting system has been developed. It has twin advantages of low background and high efficiency when compared with G. M. counter. The system uses gas flow type main counter (having window area ~16sq.cm) and guard counter (which does not have any window) operating in a G. M. region. The system works on the principle of anticoincidence where the surrounding and cosmic source pulses will be considered as coincidence pulses which can be treated as background pulses and can be rejected by the coincidence-anticoincidence circuit. The counting medium is argon gas and isopropyl alcohol vapour is used as the quenching medium. A parallel gas flow arrangement is provided to make provision for counting operation of the system. The counter assembly is kept in a 3" lead shield to reduce the background to a value near 1 count/min.

Technology Transfer & Collaboration Division, BARC, managed all activities related to this technology. It involved evaluation of the technology, documentation of the technology, fixing the TT fee to be charged, obtaining patent protection, announcement of the technology, evaluation & selection of a capable transferee, preparation & signing of the technology transfer agreement, etc. Necessary inputs were provided by RSSD.

IAEA/ RCA FINAL PROGRESS REVIEW MEETING OF TWO PROJECTS

IAEA/RCA Projects Review Meeting was organised by Isotope Applications Division, BARC, during December 6-10, 2004 at Hotel Quality Inn Parle International, Mumbai. Dr Gursharan Singh, Head, Isotope Applications Division, BARC, was the Convener of the meeting. This meeting was organised to review and evaluate the achievements of the two projects, viz., Process Diagnostics and Optimization in Petroleum Industry (RAS/8/091), and Optimisation of Materials in Industry Using On-line Bulk Analysis Techniques (RAS/08/94), and to discuss the lessons learnt from implementation of these projects.

Delegates and invitees to the IAEA/RCA Projects Review meeting.

The meeting agenda also included discussions on the strategies for propagating these technologies in all the RCA member states, strengthening regional cooperation, discussing work plan for 2005-06 and kick-starting the project inputs for 2007-08.

The meeting was inaugurated by Mr H.S. Kamath, Director, Nuclear Fuels Group, BARC. In his inaugural address, he gave a brief overview of the radioisotope applications in India and its benefit to the Indian industry. He wished the participants a successful meeting and pleasant stay in India.

Dr Gursharan Singh, Head, Isotope Applications Division, BARC, is presently the RCA Thematic Lead Country Coordinator for Industrial Sector. He welcomed the delegates and guests in the meeting and gave a bried speech about the objectives of the meeting.

Dr K. Raghuraman, RCA National representative, India, gave a brief description of RCA activities. Dr Joon-Ha Jin, Technical Officer, International Atomic Energy Agency, Vienna, gave an overview of progress achieved in RCA member states under the projects RAS/8/091 and RAS/8/094. Mr A. S. Pendharkar, Head, Tracer Technology Application Section of Isotope Applications Division of BARC proposed the vote of thanks.

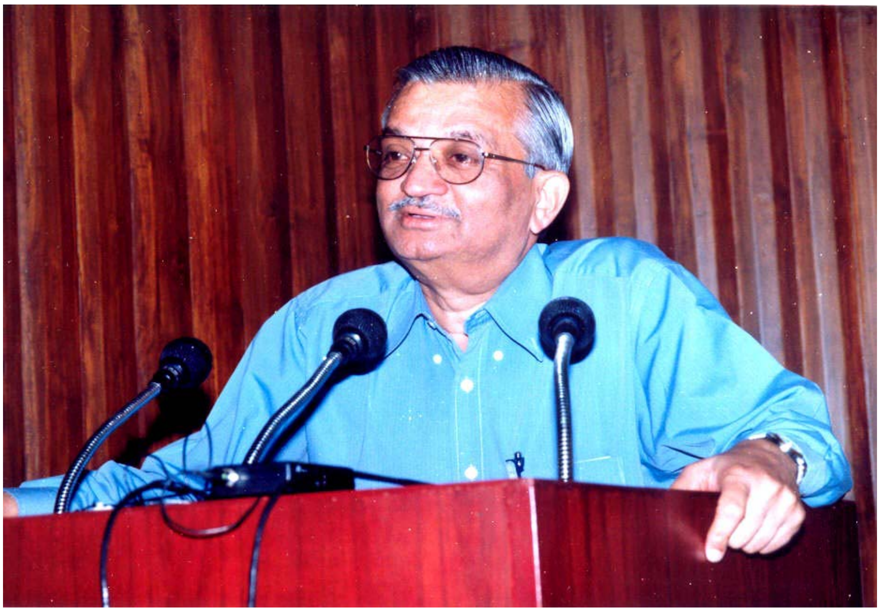
This meeting was attended by 17 participants, which included 12 participants from overseas and 5 from the host country, India. Overseas participants included one each from Australia, Bangladesh, China, Indonesia, Korea, Myanmar, Mongolia, Malaysia, Philippines, Sri Lanka, Thailand, and Dr Joon-Ha Jin, Technical Officer, International Atomic Energy Agency, Vienna. Dr Gursharan Singh was elected as Chairman of the meeting and Dr H. J. Pant as the Rapporteur. During the five days of the meeting, achievements and lessons learnt from implementation of Projects RAS/8/091and RAS/8/094 during 2003-2004 in RCA Member States were discussed. Each participant presented his country report giving details of success stories and lessons learnt in implementation of each of these two projects in 2003-04. Work plans for Project cycle 2005-06 were finalised based on the available budget. In addition, priority areas for 2007-08 were identified.

THEME MEETING ON "OUT OF CORE STRUCTURAL MATERIALS IN NUCLEAR INDUSTRY (NUSMAT 2005)"

A one-day Theme Meeting on "Out of Core Structural Materials in Nuclear Industry (NuSMat 2005)" was organised on January 28, 2005 at the AERB Auditorium, Anushaktinagar. There were 175 invitees to this Theme Meeting from different units of DAE, industry and educational/research institutes in the country. The meeting was organised under the aegis of the Board of Research in Nuclear Sciences (BRNS).

The Theme Meeting was inaugurated by Dr Anil Kakodkar, Secretary to the Department of Atomic Energy, Government of India and Chairman, Atomic Energy Commission. Dr Kakodkar complimented the organisers for choosing such a unique topic for discussion. He pointed out that DAE has a comprehensive research and development programme on such materials and these materials are used in power projects and allied plants in large quantities. Dr Kakodkar said that the rich experience on out of core materials in nuclear industry is mainly driven by the problems faced in the field and also by interest of

Dr Anil Kakodkar, Chairman, Atomic Energy Commission, Dr S. Banerjee, Director, BARC, and Dr P. K. De, Head, Materials Science Division, BARC, at the inaugural function of the Theme Meeting, NuSMat 2005.



Dr Anil Kakodkar, Chairman, Atomic Energy Commission, delivering the inaugural speech at the Theme Meeting, NuSMat 2005.

researchers in these materials. The close interaction of plant personnel and researchers within the Department has led to resolution of many problems in fabrication and operation of components used in locations that are outside the core. Dr Anil Kakodkar listed three main "themes" on which work needs to be done to solve pressing problems. The first theme is to establish a criterion for establishing healthiness/condition of operating components where access is not possible or is very difficult. He stressed that controlled experiments are required to develop techniques and methodologies to assess the condition of such components. The second theme is to adopt a multidisciplinary approach to solving problems faced in plants. Resolution of such problems requires a greater interdisciplinary approach. He cited the case of Intergranular Stress Corrosion Cracking (IGSCC) in TAPS which is a generic cracking problem faced worldwide. Dr Kakodkar opined that such problems in TAPS are not so severe, probably because later designs incorporated tougher seismic designs making the piping stiffer. The third theme is to include concrete as a structural material when we consider out of core structural materials in nuclear industry. The long design life of newer reactors requires that we understand and resolve the issues related to creep and corrosion of concrete over such a long period. He stressed that to resolve the issues related to concrete, civil engineers and materials engineers need to work together.

In the Theme Address, Dr Srikumar Banerjee, Director, BARC, pointed out that this was the first time that there is a collective focus on materials used for out of core components in the nuclear industry. He stressed that out of core materials in nuclear industry are the same as used in other power plants. However, there are some specific requirements imposed because the cost of failure in nuclear industry is much more and these materials are of immense functional importance to the nuclear power generation programme. He illustrated with examples, the experience in DAE with out of core materials which had necessitated a lot of research and developmental work in DAE. The cracking of low alloy steel used in the End Shield of MAPS, the incident involving turbine blades at NAPS, the Reactor Pressure Vessel (RPV) steel to be used for VVERs, the incident at Baroda Heavy Water Plant due to hydrogen embrittlement are some of the examples where the "out of core" materials posed tough challenges to the materials and nuclear community.

Dr Banerjee pointed out that the materials scientists have been always aiming at increasing the strength of materials without sacrificing its toughness. The High Strength Low Alloy (HSLA) steels have been a topic of immense R & D. Similarly, understanding the structure and property correlation in nickel based alloys has been a challenging experience. The R & D work in these fields has been useful for Heavy Water Plants. Dr. Banerjee said that on out of core materials, both the research and experience in the industry is at a mature stage. However, we need to look for requirements 20 years from now. At that stage, ceramic and carbon based materials will be used in high temperature reactors. Refractory metals and high density graphite, carbon-carbon composites will be in demand for the reactors using liquid metals as a coolant.

Mr B. P. Sharma, Convener of the Theme Meeting and Associate Director (S), Materials Group, BARC, welcomed the participants. He pointed out that there have been two major national conferences organised recently in the DAE focusing on Zirconium based alloys used in the nuclear industry. There had been no meeting organised earlier to debate on the challenges faced for materials used in out of core components. Mr B. P. Sharma pointed out that any failure occurring in out of core components can also lead to shut down of the reactor and heavy costs. He encouraged the participants to interact with the speakers and experts present at the meeting to debate the problems and identify areas for focused research to resolve these issues. Mr B. P. Sharma said that a feature of this Theme Meeting is the participation of representatives from associated industry and research/academic institutes. He hoped that the technical talks during the meeting will give an overview of the challenges in the field of out of core structural materials and that scientists from other research institutions can work out collaborative research projects that will be relevant to DAE.

The first technical session was chaired by Mr B. B. Dixit, Executive Director (E), NPCIL. There were four talks by Dr P. K. De, Head, Materials Science Division, BARC, Dr Baldev Raj, Director, IGCAR, Mr S. C. Hiremath, Chief Executive, HWB and Mr A. B. Ghare, Executive Director, NPCIL. The second technical session was chaired by Dr Baldev Raj. There were technical talks by Mr R. K. Sinha, Director, RD&DG, BARC, Mr K.B. Dixit, Executive Director (E), NPCIL and Mr R. S. Yadav, Head, LWRD, BARC. The third technical session was chaired by Prof B. P. Kashyap, Head, Metallurgical Engineering and Materials Science at IIT, Bombay. There were technical talks by Dr S. V. Narsimhan, Head, WSCL, BARC, Prof. U. K. Chatterjee, IIT, Kharagpur and Dr K. Elya Perumal. A rich mix of participants engaged in design, fabrication, operation and research from the DAE, together with participants from associated industry and educational institutes, had good interaction and discussion during the meeting. The main issues related to structural materials used in out of core components in nuclear industry were highlighted and discussed.

TROMBAY SYMPOSIUM "ON DESALINATION & WATER RE-USE"

Indian Desalination Association (InDA), in association with Board of Research in Nuclear Sciences, Department of Atomic Energy, organised the Trombay Symposium on "Desalination & Water Re-use (TSDWR-05)" at the Multipurpose Hall of BARC Guest House & Training School Hostel, Anushaktinagar, during February 10-11, 2005. The symposium was inaugurated on February 10, 2005 by Dr. Anil Kakodkar, Chairman, AEC & Secretary, DAE, Government of India.

In his inaugural address, Dr Kakodkar highlighted the pressure on water resource with increasing population. He stressed the need for having residential colonies with minimal water discharge and rain water harvesting and said it may be cheaper to desalinate sea water than transport potable water through tankers. He mentioned about BARC technology of producing dual quality desalinated water for process requirement from low pressure waste steam from nuclear power plants and mixing it with reverse osmosis (RO) water to provide potable water. He emphasised the need for R&D activities to develop better long lasting RO membranes and effective heat transfer surfaces and making linkages with conventional knowledge.

Dr S. Banerjee, Director, BARC, presided over the function. While addressing the scientists, he referred to RO unit, which has been setup by BARC in Tsunami affected areas. He highlighted the need for nuclear desalination in coastal areas. He referred to barge mounted RO plants being developed by BARC for making water available at different locations depending on need.

Mr D.S. Shukla, Director, Chemical Engineering & Technology Group, BARC, stressed that it is essential to make available water at end use at affordable cost. This calls for review of state-of-the-art of various components of integrated water resource management, desalination and water re-use. With this objective, BRNS and Indian Desalination Association jointly organised a 2-day Trombay Symposium on "Desalination and

Inauguration of exhibition during TSDWR-05 by Dr Anil Kakodkar, Chairman, AEC

Inaugural address by Dr Anil Kakodkar, Chairman, AEC. Others sitting on the dais are (from left) : Dr S. Prabhakar, Secretary, Organising Committee, Mr D.S. Shukla, Director, Chemial Engineering & Technology Group, BARC, Dr S. Banerjee, Director, BARC, and Dr P.K.Tewari, Head, Desalination Division, BARC

Water Re-use (TSDWR-2005)" during February 10-11, 2005. Earlier, Dr P.K. Tewari, Head, Desalination Division, BARC, and Chairman of the Symposium Organising Committee, welcomed the participants and added that the symposium has been organised to bring together the Desalination Technologies and Water Management experts from the government sector, industries, R&D and academia from the country and abroad to share their experience. Dr S. Prabhakar, Secretary, Organising Committee, proposed the vote of thanks.

There were about 200 participants from India and abroad namely Israel, Italy, Muscat, Singapore and USA. In all, 14 invited talks and 30 contributory papers were presented in 8 sessions including inaugural, panel discussion and concluding sessions in the two-day symposium. All the papers were divided into six main categories: Desalination Technologies-1 and 2, Water Quality and Quantity Management, Nuclear Desalination, Water Recovery and Integrated Water Resource Management. Invited talks were given by well known experts in respective fields from India and abroad. A brief summary of all the poster papers was presented by the co-chair person of the respective sessions. A panel discussion on 'Desalination & water re-use - a cost effective and inevitable option' was organised in which experts from R&D institutions, government organisations, user sector and industries presented their view points, which was followed by the views from the audience.

The industry response to this symposium was very heartening. In view of the industrial significance of the desalination and water re-use, an exhibition of desalination and water purification technology related products, equipments, accessories, etc. by different manufacturers and suppliers was organised at the venue of the symposium hall. Six of the licensees, to whom Desalination Division has transferred the know-how, have participated in the exhibition. The interest shown by the exhibitors reveal that the industry has come of age and the advances that have taken place over the years is quite significant.

A souvenir and book of abstracts was also brought out on this occasion. These were designed to provide useful information on the symposium, details about Indian Desalination Association, an affiliate of International Desalination Association and advertisements related to desalination and water re-use. Selected papers are being published in a special issue of International Journal of Nuclear Desalination.

FOURTEENTH NATIONAL SYMPOSIUM ON ENVIRONMENT (NSE-14)

Sustainable water resource management balances the needs for protection of the environment and public health, while not compromising the ability of future generations to procure water to meet their basic needs. It also creates a shift from the traditional view of water as a commodity, managed solely for the convenience of humans to a more balanced effort to maintain the water needs of the entire ecosystem of which humans are a part.

Water pollution is one of the most serious environmental problems we face today. The genesis of water pollution is the effluents from urban sources and industrial discharges. Also, the solid effluents getting leached out by rain water cause pollution of water bodies. Additionally, the air water exchange of pollutants adds to the pollution load of water resources. Therefore, the problem has to be addressed in proper prospective. Administrative and local bodies must work together to address the environmental pollution of water due to agricultural modernisation and industrialisation within an appropriate regulatory and institutional frame-work.

Since 1992, the Board of Research in Nuclear Sciences, Department of Atomic Energy, has been organising National Symposia on Environment every year with a focal theme on specific environmental issues. In view of this, the Fourteenth National Symposium on Environment (NSE-14) is being held at the Department of Physics, Osmania University, Hyderabad, during June 5-7, 2005, with the focal theme, "Water Resources and Environment". The symposium will cover the following major topics :

1. Water quality monitoring & modelling
2. Water and wastewater treatment and management
3. Environmental impact assessment
4. Mining and water resources
5. Mitigation of aquatic pollution
6. Environmental pollution in air, water and soil matrices
7. Environmental awareness education and legislation

For further details contact:

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E-mail : pyreddy@osmania.ac.in.
Website : http://www.osmania.ac.in

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

Dr A.M. Shaikh

- डॉ. ए.एम. शेख (एस एस पी डी), डॉ. पी.आर. वैद्या तथा श्री बी.के. शाह (ए एफ डी), श्री एस.गंगोत्रा एवं श्री के.सी.साहू (पी


Dr P.R. Vaidya


B.K. Shah


S. Gangotra


K.C. Sahoo

आइ ई डी), भा.प.अ. केंद्र को "बेस्ट पेपर पब्लिश्ड इन आर एन्ड डी की श्रेणी के अंतर्गत जरनल ऑफ नॉन डेस्ट्रक्टिव टेस्टिंग एन्ड इवेलुएशन" में प्रकाशित शोध-पत्र के लिए "आइ एस एन टी राष्ट्रीय एन डी टी पुरस्कार 2004" प्रदान किया गया । ए.एम. शेख, पी.आर. वैद्या, बी.के. शाह, एस.गंगोत्रा एवं के.सी.साहू के द्वारा "एप्लिकेशन ऑफ न्यूट्रान रेडियोग्राफी एन्ड न्यूट्रान डिफ्रेक्शन टेक्नीक्स इन स्टडी ऑफ जिरकोनियम हाइड्राइड ब्लिस्टर्स इन जिरकोनियम बेस्ड प्रशर ट्यूब मेटीरियल्स नामक शोध-पत्र दिसंबर 2003 के जरनल ऑफ नॉन डेस्ट्रक्टिव इवेलुएशन अंक में प्रकाशित हुआ था। डॉ. ए.एम. शेख ने दिसंबर 9, 2004 को होटल ल मेरिडियन, पुणे में "एन डी ई 2004" के उद्घाटन समारोह में भारतीय अंतरिक्ष विभाग के अध्यक्ष श्री जी.माधवन नायर के द्वारा पुरस्कार प्राप्त किया। इस पुरस्कार में एक प्रशस्ति-पत्र तथा 10,000/- रुपये निहित हैं।

Dr A.M. Shaikh (SSPD), Dr P.R. Vaidya and Mr B.K. Shah (AFD), Mr S. Gangotra and Mr K.C. Sahoo (PIED), BARC, have been awarded the "ISNT National NDT Award 2004" under the category "Best Paper published in R&D" in *Journal of Non Destructive Testing & Evaluation*. The paper entitled, "Application of neutron radiography and neutron diffraction techniques in study of zirconium hydride blisters in zirconium based pressure tube materials, " by A.M. Shaikh, P.R. Vaidya, B.K. Shah, S. Gangotra and K.C. Sahoo was published in the December 2003 issue of *Journal of Non Destructive Testing & Evaluation*. Dr A.M. Shaikh received the award from Mr G. Madhavan Nair, Chairman, Department of Space, Government of India, at the inaugural function of "NDE2004" at Hotel La Meridian, Pune, on December 9, 2004. The award included a citation and Rs. 10,000/-.


R.S. Sengar


K.D. Lagoo


R.K. Puri


Manjit Singh


A.V.S.S.N. Rao

• श्री रतनेश सिंह सेंगर, श्री केतन डी. लागू, श्री आर.के. पुरी एवं श्री मंजीत सिंह, रिमोट हेंडलिंग एन्ड रोबोटिक्स प्रभाग तथा श्री ए.वी एस. एस. नारायण राव, मोलिक्यूलर बायोलोजी प्रभाग भा.प.अ. केंद्र के द्वारा लिखित एक तकनीकी शोध-पत्र "डेवलोप्मेंट ऑफ ए 3-एक्सिस रोबोटिक सिस्टम फॉर मेकिंग डी एन ए माइक्रोएरेज़" ने सेन्सर्स / इन्सट्रूमेंटेशन के क्षेत्र में श्रेष्ठ शोध-पत्र पुरस्कार प्राप्त किया।

यह शोध-पत्र दिसंबर 15-18, 2004 के दौरान चिन्नई में आयोजित ट्रंडस इन इन्डस्ट्रियल मैजरमेन्ट एन्ड ऑटोमेशन (टी आइ एम ए-2004) के चौथे अन्तर्राष्ट्रीय सम्मेलन में प्रस्तुत किया गया।

A technical paper titled, "Development of a 3-axes robotic system for making DNA microarrays", authored by Ratnesh Singh Sengar, Ketan D. Lagoo, R.K. Puri and Manjit Singh of Division of Remote Handling & Robotics and A.V.S.S. Narayana Rao of Molecular Biology Division, BARC has won the Best Paper award in the field of Sensors/ Instrumentation. This paper was presented at 4th International Conference on "Trends in Industrial Measurement & Automation (TIMA-2004)" held at Chennai during December 15 - 18, 2004.

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