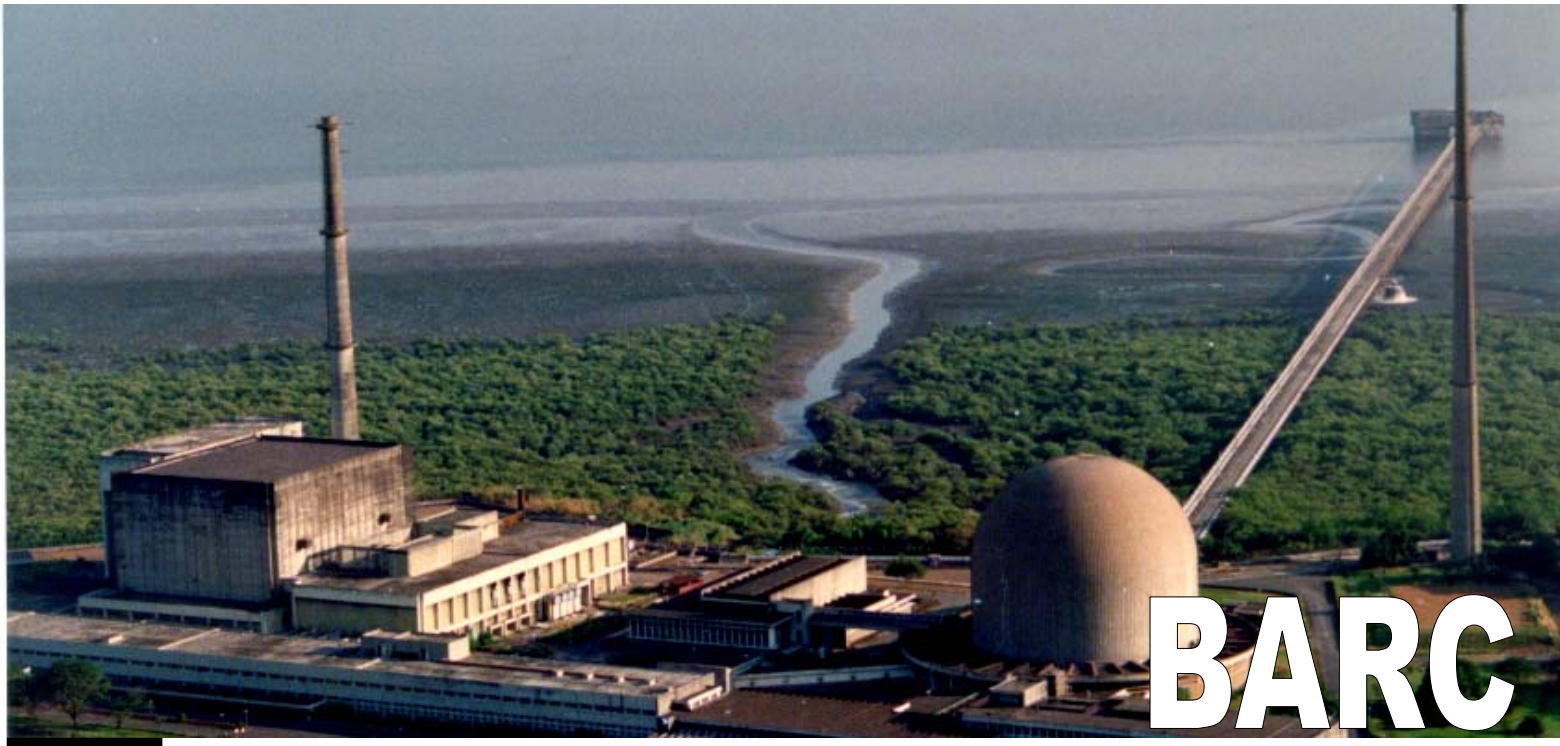

BARC NEWSLETTER

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Contents

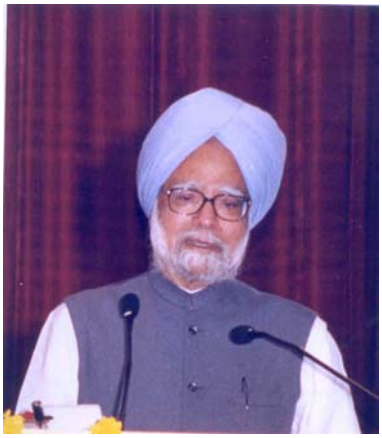
1. Prime Minister visited BARC 1
2. Solid state nuclear track detectors and their applications 6
3. Synchroscope simulator for nuclear power plant training simulator 15
4. National Science Day 18
5. Fourth DAE-BRNS National Laser Symposium 20
6. Seminar on "ECIL instruments for nuclear applications" 21
7. 14th Training Workshop on "Planning, preparedness and response to radio-logical emergencies" 22
8. DAE-BRNS symposium on "Electron beam technology and applications" 24
9. World nuclear power scenario 26

PRIME MINISTER VISITED BARC

Hon'ble Prime Minister of India, Dr. Manmohan Singh, visited BARC on June 4, 2005. He went around an exhibition specifically set up for the occasion. He was accompanied by Hon'ble Minister of State, Mr Prithvi Raj Chavan and Mr M.K. Narayanan, National Security Advisor. Former Chairmen of Atomic Energy Commission, Dr H.N. Sethna and Dr R. Chidambaram, were also present. Hon'ble Prime Minister addressed the senior scientists and engineers of the Department of Atomic Energy (DAE). Dr Anil Kakodkar, Chairman, AEC, welcomed the guests and Dr S. Banerjee, Director, BARC, gave the vote of thanks.

Dr K.T. Dinshaw, Director, Tata Memorial Centre, gave a live demonstration of the Tele-Medicine Session between Tata Memorial Hospital, Mumbai, and Dr. B. Barooah Cancer Institute, Guwahati. She also informed that the Cobalt-60 tele-therapy machine, BHABHATRON-1, developed by BARC, has been used for the treatment of a patient for the first time on that day.

In his speech, Dr Manmohan Singh announced the approval of the proposal submitted by the Department of Atomic Energy to set up Homi Bhabha National Institute – a deemed to be University. The full text of the PM's address is reproduced below.



Hon'ble Prime Minister Dr Manmohan Singh addressing the august gathering of senior scientists and engineers of DAE and other dignitaries

PM's address to the Scientific Fraternity of BARC

Chairman of the Atomic Energy Commission, Dr Anill Kakodkar, Director of BARC, Dr S. Banerjee, Dr Homi Sethna, Dr Chidambaram, Members of the BARC Fraternity, Ladies and Gentlemen,

I am delighted to be here today. We live in an age in which human knowledge is growing at an exponential pace. It is a pace that was unthinkable only a few decades ago. Human knowledge and science and technology are the

On the dais seen from left to right are : Dr S. Banerjee, Director, BARC, Mr Prithvi Raj Chavan, Hon'ble Minister of State, Dr Manmohan Singh, Hon'ble Prime Minister of India, Mr M.K. Narayanan, National Security Advisor and Dr Anil Kakodkar, Chairman, Atomic Energy Commission and Secretary to Government of India

new determinants of national development. In the gigantic task of national development and nation building that is before us, the members of the BARC fraternity have played an outstanding role, and I salute you for it. I thank you on behalf of the nation for your efforts.

It is, therefore, a pleasure for me to speak to such a distinguished gathering of scientists today. This great national enterprise that BARC is, takes its name after the Father of India's Atomic Energy Programme – Dr. Homi Bhabha, a great visionary and a great patriot who laid the foundations of a self-reliant nuclear programme for India. I pay homage to his memory and I salute his vision.

The Bhabha Atomic Research Centre has gained national and international recognition as the mother institution of our Atomic Energy Programme. BARC has been instrumental in the birth of a whole host of DAE institutions, ranging from cutting edge R&D to commercial operations. The BARC Training School has become the primary source of human resource talent for the entire Department of Atomic Energy.

Our nuclear programme has benefited from a generation of outstanding scientists and engineers. We recall with gratitude the contributions made by my friend and colleague, Dr Homi Sethna, Dr P.K. Iyengar, Dr M. R. Srinivasan, Dr Chidambaram and the late Dr Raja Ramanna. Dr Kakodkar is carrying on this great tradition and I compliment him and his colleagues for their dedicated work. All these outstanding scientists have been nurtured by this great centre of scientific excellence. This is a fitting example of how great institutions and outstanding individuals reinforce each other, a model we must replicate elsewhere in our country, in the management of our affairs and in our academic institutions.

The Department of Atomic Energy, which marked the Golden Jubilee of its establishment last year,

Highlights of PM's visit to BARC

- PM approves setting up of the Homi Bhabha National Institute, a deemed to be University.
- A special Exhibition comprising three sections, viz., Mastering the Nuclear Fuel Cycle, High Tech developments, and Technologies for better quality of life, was viewed and appreciated by the PM.
- A live demonstration of the Tele-Medicine Session between Tata Memorial Hospital, Mumbai, and Dr B. Barooah Cancer Institute, Guwahati, was arranged.

PM APPROVES HBNI

Hon'ble Prime Minister of India, Dr. Manmohan Singh referred to BARC Training School as the "Primary source of human resource talent for the entire Department of Atomic Energy. He appreciated the efforts of DAE to attract the best scientific talent in the country and encouraging greater student involvement in its research programmes and strengthening linkages with our University system.

The PM announced the approval of the setting up of Homi Bhabha National Institute (HBNI) for bringing together ten premier institutions all over the country under a single research driven framework. He hoped that the establishment of HBNI will ensure human resource base for our scientific establishments to remain at the forefront of the pursuit of excellence, comparable with the best global standards.

has made tremendous strides ranging from fundamental scientific research to development and commercial applications of nuclear energy. Our Scientists have — and I say it with great pride — mastered all aspects of nuclear fuel cycle technology. This is an achievement for which the nation is grateful to them. They have also achieved high standards in safety and environment management. Nuclear technology developed in this Centre has found applications in industry, health, agriculture, food preservation, urban waste management and desalination.

It is a matter of national pride that India is among a select group of countries with advanced capabilities to utilise the entire gamut of fuel cycle operations. The technology to recover plutonium from irradiated nuclear fuel and use it to produce nuclear power in thermal as well as in fast reactors, making use of our vast thorium reserves, is critical to Dr Bhabha's vision of a phased but unconstrained development of our nuclear power programme. We remain committed to doing all that is necessary to realise Dr Bhabha's vision. Our Government will ensure that the resource and capability base that BARC represents will be nurtured to meet our security needs in the years ahead.

Hon'ble Prime Minister Dr Manmohan Singh visiting the exhibition at the Central Complex auditorium at BARC. Seen along with him are Dr Anil Kakodkar, Chairman, Atomic Energy Commission and Secretary to Government of India and Dr S. Banerjee, Director, BARC

In the exhibition, Hon'ble Prime Minister Dr Manmohan Singh is greeted with a bouquet by a Remote Inspection Device developed by BARC.

To ensure our energy security in future, we must recognise that nuclear energy is an important component of our overall energy basket. We cannot allow energy constraints to retard our economic and social growth. Nuclear energy is a clean and safe alternative to our dependence on fossil fuels. It is, therefore, imperative for the country to embark on a major expansion of nuclear energy. Our objective is to generate at least 20,000 MW of nuclear power by the year 2020 and we are determined to achieve this target.

Such an expansion will require a focused national effort. However, when we succeed, it will provide considerable scope for the establishment of nuclear power plants through international collaboration. We hope that countries with advanced nuclear power industries will come forward to make use of the growing opportunities in India for cooperation in civilian nuclear energy. This is not just in India's interest, but indeed in the interests of the international community as a whole, worried as we all are by global warming and all that goes with it.

India is a responsible nuclear power. While we are determined to utilise fully the advanced technologies in our possession – both civilian and strategic, we are also prepared for a constructive dialogue with the international community to remove hindrances to a free flow of nuclear materials, technology and know-how. Our non-proliferation and export control credentials are impeccable and have been further strengthened through a comprehensive legislative action against WMD proliferation that our Parliament passed only a few weeks ago.

Our nuclear programme has reached global standards of excellence. Our scientific and

Hon'ble Prime Minister Dr Manmohan Singh having a chat with former Chairmen, AEC, Dr H.N. Sethna, Dr R. Chidambaram and the present Chairman, AEC, Dr Anil Kakodkar. Also seen in the photograph are former Director, Dr B. Bhattacharjee and Hon'ble Minister of State Mr Prithvi Raj Chavan

technological achievements have given us the will and confidence to explore enhanced interactions and exchanges with the outside world. Artificial barriers and technology denial regimes are an anachronism in the age of globalisation, and must be progressively dismantled. Given our scientific credentials, we can add value to international cooperative endeavours. India would like to participate in all efforts to find alternatives to traditional sources of energy.

LIVE TELEMEDICINE SESSION

Tata Memorial Centre has established Telemedicine Facility at the Tata Memorial Hospital (TMH), Parel, Mumbai. Using the Telemedicine facility, cancer patients in distant areas can consult expert doctors of TMH on-line from the local hospitals in presence of the local doctors who would follow up the case. Such a Telemedicine demonstration session between TMH and Dr. B. Barooah Cancer Institute (BBCI), Guwahati was projected in the Central Complex Auditorium on June 4, 2005.

The set up comprised of videoconference equipment installed at three locations, namely, TMH, BBCI and BARC, with TMH acting as a multiparty hub. The connection between TMH and Guwahati was established using VSAT link over INSAT series satellite, while the link between TMH and BARC was over the DAE's wide area network ANUNET, backed up by ISDN dial up lines. The bandwidth used for the videoconference session was 256 kbps. The consultation session between doctors at TMH and Guwahati was witnessed by the audience in Central Complex Auditorium. CT scan images of the patients used during the consultation also were displayed at all the three locations simultaneously.

The most valuable resource in any scientific endeavour is its human resource base. This Centre must continue to attract the best scientific talent in the country. I am glad that the Department of Atomic Energy is encouraging greater student involvement in its research programmes and is strengthening linkages with our university system.

I am happy to announce today that the Department's proposal to set up a Dr Homi Bhabha National Institute has been approved. This will bring together ten premier institutions all over the country under a single research-driven framework. This will help ensure that our scientists and our scientific establishments remain at the forefront of the pursuit of excellence, comparable with the best global standards.

In conclusion, let me once again convey my deep appreciation for your dedication and your deep commitment to our nation's growth. The nation is proud of the achievements of our scientists and technologists working dedicatedly here to develop our capability in atomic energy. In this journey of excellence, I assure you of the sustained support of the Government and our people. You should remain in the forefront of the national scientific endeavour. That is my prayer, that is my hope. May your path be blessed.

Thank you.

SOLID STATE NUCLEAR TRACK DETECTORS AND THEIR APPLICATIONS

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Introduction

Solid State Nuclear Track Detectors (SSNTDs) [1-2] are insulating solids both naturally occurring and man-made. There are several types of these detectors including inorganic crystals, glasses and plastics. When a heavily ionising charged particle passes through such insulating solids, it leaves a narrow trail of damage about 50 Å in diameter along its path. This is called 'Latent Track' as it cannot be seen with the naked eye. It is possible to view this latent track with an electron microscope. The exact nature of the physical and chemical changes occurring at the damage site depends on the charge (Z) and velocity ($\beta = v/c$, where v is the particle velocity and c is the velocity of light) of the particle, on the chemical structure of the detector material and also on the environmental conditions like temperature and pressure. These latent tracks can be enlarged / developed so that they can be viewed under an optical microscope by etching with some chemicals such as sodium hydroxide and hydrofluoric acid. Examples of some commonly used solid state nuclear track detectors are given in Table-1. A list of chemical etchants generally used along with the etching conditions for different detectors, particle sensitivity and the critical angle of etching are also given in Table - 1. General properties of some of the most widely used plastic track detectors are listed in Table – 2.

Cellulose nitrate was the first detector used for recording alpha tracks. It has poor sensitivity and is now replaced by a more sensitive detector called CR-39. Polycarbonate detectors such as Lexan are generally used for recording fission fragment tracks. Some photographs of nuclear tracks developed in Lexan and CR-39 track detectors are given in Figs.1, 2 and 3.

Each detector is characterised by a critical value of energy loss rate by the charged particle. Only those charged particles which give up energy

Table – 1 : Examples of Solid State Nuclear Track Detectors

Category	Detector Material	General Etching Conditions	Lightest Detectable Particle	Critical Angle Q_c
Minerals/ Crystals	Olivine	KOH Soln., 160°C, 6 min; 10 % HF, 23°C, 30 sec.	Fe	
	Zircon	85 % H_3PO_4, 500°C, 1 min.	Ca	
	Quartz	KOH Soln., 210°C, 10 min.	Ar (100 MeV)	
	Mica	48 % HF, 23°C, 3 Sec- 40 min.	Ne(20 MeV)	4° 30′
Glasses	Sodalime glass	48 % HF, 23°C, 3 Sec.	Ne(20 MeV)	~ 50°
	Phosphate glass	48 % HF, 23°C, 3 Sec.	F (20 MeV)	1-5°
Plastics	Polycarbonate Plastics (Lexan, Makrafol, Milar)	6 N NaOH, 60°C, 60 min.	He (0.3 MeV)	~ 2-3°
	Cellulose Nitrate (Daicell, LR-115, CA-80-15)	3-6N NaOH, 50°C, 40 min.	H (0.5 MeV)	~ 4-8°
	Allyldiglycol Polycarbonate (CR-39)	6 N NaOH, 70°C, 1-4 hrs.	H (1.0 MeV)	~ 10°

Table – 2 : Properties of some Plastic Nuclear Track Detectors

SSNTD	CN	PC	PET	CR-39
Composition	$C_6H_8O_9N_2$	$C_{16}H_{14}O_3$	$C_{10}H_8O_4$	$C_{12}H_{18}O_7$
Density (gm/cm^3)	1.33 - 1.60	1.20	1.39	1.30
Foil thickness	100-1000 μm	75-250 μm	100-200 μm	500 μm
Uniformity	Poor	Good	Good	Good
Surface View	Smooth, fairly high background	Smooth, no background pits	Smooth, no background pits	Smooth, moderate background
Chemical Etchant	NaOH aq. sol.	NaOH aq. sol.	NaOH aq. sol.	NaOH aq. sol.

CN = Cellulose nitrate, PC = Polycarbonate, PET = Polyethylene terphthalate and CR-39 = Allyl diglycol carbonate

Table – 3 : Detection thresholds of some Nuclear Track Detectors

Detector	Detection Threshold	Remarks
Inorganic	15 MeV/mg.cm^2	-
Lexan, Makrofol etc.	4 MeV/mg.cm^2	
CN (Cellulose Nitrate)	1 MeV/mg.cm^2	
CR-39	< 0.05 MeV/mg.cm^2	~ 100 times more sensitive than polycarbonates like Lexan
SR-86 (It is CR-39 containing sulphonate linkages to a certain extent)	-	Three times more sensitive than CR-39 for alphas and high energy heavy ions.

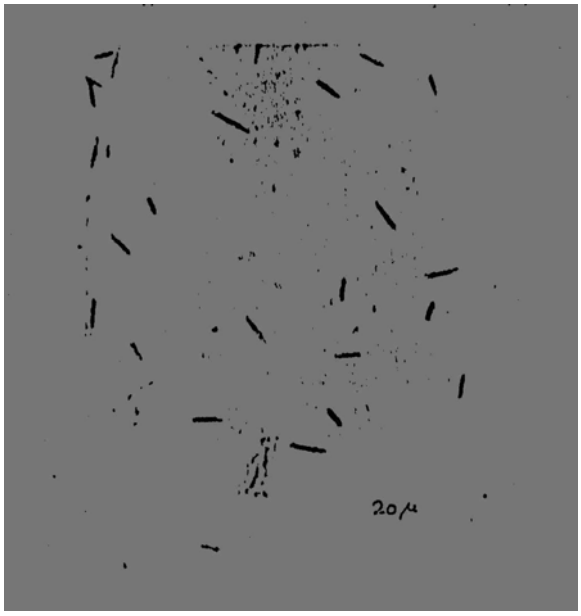

Fig.1 Fission fragment tracks in Lexan

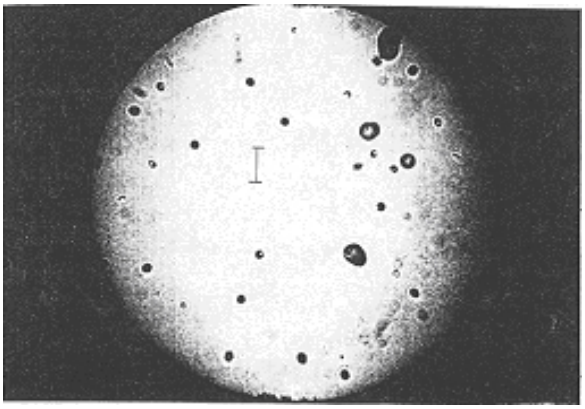

Fig. 2 Fission fragment & alpha tracks in CR-39

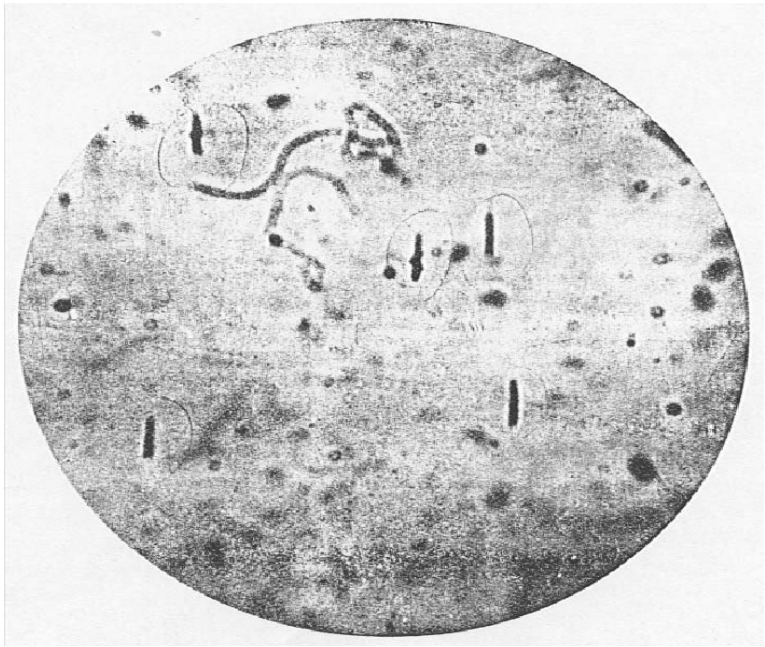

Fig. 3 Oriented fission tracks in Lexan from 60MeV helium ion induced fission of ^{159}Tb

exceeding the critical value alone can produce etchable tracks. The detection thresholds of nuclear track detectors can be specified in terms of their energy loss rates, as shown in Table - 3. A measure of the sensitivity of a track detector can be expressed in terms of the minimum value of $(Z/\beta)_{min.}$ the ratio of the charge, Z, to the speed, ($\beta = v/c$),for a charged particle to produce an etchable track in that detector. The more sensitive the detector, the smaller is the value of $(Z/\beta)_{min.}$. Its values are 6, 30, 40 and 60 for CR-39, Cellulose Nitrate (CN), Cellulose Acetate (CA) and Lexan respectively. Thus CR-39 is one of the most sensitive detector, and inorganic materials like Chronar, Melinex, Mica and Meteoritic minerals are amongst the poor sensitivity detectors. Most of the known track-recording polymers have sensitivities $(Z/\beta)_{min.}$ between about 5 and 100. Track recording sensitivity for minerals and glasses range from about 150 to 450. High sensitive detectors are also characterised by high G scission (number of chain scissions per 100 eV of energy deposited) and low G cross link (number of cross links per 100 eV of energy deposited).

Special Features of SSNTDs

The areas of potential applications of Solid State Nuclear Track Detectors are growing rapidly. They have been employed in various fields and in particular to nuclear science and technology. The disciplines where track detectors are regularly employed are: a) nuclear physics, b) nuclear imaging, c) nuclear technology, d) space physics, e) microanalysis, f) mine safety, g) environmental research, h) uranium prospecting i) bio-medical sciences, j) material sciences, and k) geological sciences. Some of the special features of these detectors which make them extremely valuable for

wide range of studies are as follows :

(i) They are extremely simple to use and are inexpensive.

(ii) A wide variety of detectors with different sensitivities to charged particles are available for the user to choose from to meet his specific needs. This makes them attractive for investigation of specific, rare and low-cross section events in the presence of a host of unwanted background radiations, e.g. measurement of radial burn-up profile of highly irradiated fuel elements by alpha radiography. Again, the sharp threshold of mica track detector, for example, allows bombardment with a flood of high energy alpha particles that do not themselves leave tracks but induce rare nuclear reactions which release heavy ionising track-producing particles. The lowest cross section measured for the helium ion-induced fission of Au^{197} was about 3×10^{-35} cm^2, almost 20 trillion times smaller than the thermal neutron fission cross section of ^{235}U [3] .

(iii) The integrating nature of the detectors allows events to be accumulated over long periods of time. The stored information is preserved almost indefinitely under normal temperature and pressure and other environmental conditions. The recorded tracks can be examined any time after the experiment, even after several years. There is no radioactive decay or electronics breakdown to worry about. It is estimated from track fading kinetics studies that the tracks recorded in zircon can be preserved for almost 10^{39} years under normal temperature and pressure [4]. The cumulative nature of stored information helps in enhancing the sensitivity of these detectors.

(iv) They are amenable to different geometrical arrangements such as 2π, 4π, forward and backward geometry, etc.

(v) They can be used in any size; small size allows them to be used in remote and difficult-to-reach experimental locations.

These features of SSNTDs when coupled with some ingenuity on the part of the investigator make them unique among experimental tools that are generally available for studies involving ionising particles.

Track Observation and Counting

The most common method of viewing and making quantitative measurements of the observable track parameters like number, length, diameter, etc. is through an optical microscope with calibrated eye pieces and mechanical stages under transmitted light, and with magnifications ranging from 400-1000 X. Advanced and automatic track counting systems based on new optical devices coupled with microprocessors have also been employed to count the tracks. In one such device, images of the tracks focused under the microscope, scanned through a camera to an image digitizer in the PC. These digital images are subsequently analysed by a software called Image Pro Plus.

General Methodology

The most direct and simplest use of the detectors involves exposure of a target, say of a fission material like U in contact with the track detector, to a flux of neutrons or charged particles, and the resulting energetic reaction products (in this case fission fragments) leave their tracks on the detector. The number of tracks, (T), is proportional to the number of target atoms (n), the flux (ϕ), the reaction cross section (σ), and the time of irradiation (t).

$$T \propto n\sigma\phi t; \quad \text{or } T = K_{dry}\, n\sigma\phi t$$

where K_{dry} = Registration Efficiency.

If W is the weight of the element in grams (g) containing a weight fraction, X of the fissile isotope of mass A and N is the Avogadro number, then the above equation becomes

$$T = K_{dry} \frac{WXN}{A} \sigma\phi t$$

Depending upon the need of the user, it is possible to measure any of the parameters, viz cross section (σ), flux (ϕ) or amount (n) of the target material, if K_{dry} is known. The charged particle track registration technique employing *n* SSNTDs is also used in many basic research studies in other fields of science.

In analytical applications, nuclear tracks are generally registered from thin sources of the samples in contact with the SSNTDs in 2π geometry and the registration efficiency is close to unity. Registration efficiencies of some commonly used detectors are given in Table-4.

Table – 4 : Registration Efficiency (K_{dry}) values of some detectors in 2π geometry [5]

Detector	K_{dry}*	Q_c**
Lexan	0.958	2° 30'
Melinex – O	0.908	5° 15'
Makrofol – E	0.952	3°
Mica	0.918	4° 30'

* The overall uncertainties on these values were about 3-5% [5].

**Q_c (critical angle of etching)= Sin^{-1} (Vb/Vt) where Vb is the bulk etch rate and Vt is the track etch rate

However, due to the non-uniformity of the source material, usually prepared by evaporation or electroplating method, the distribution of the tracks in different areas over the surface of the detector is not uniform. Hence, for any quantitative determination, it is essential to count the total number of tracks over the entire detector area. To overcome these difficulties, the simple procedure of track registration in SSNTDs immersed in solution [5-6] media should be considered as a significant development. When the tracks are registered from a homogeneous solution medium, the number of tracks per unit area of the detector (track density, T_d) obtained by scanning a small representative detector area

Table – 5 : Registration Efficiency (K_{wet}) values of some common detectors in solution medium [5]

Charged Particle	Detector	K_{wet} Values (in 10^{-4} cm)*
Fission fragment from ^{235}U fission	Lexan	8.1
	Makrofol	6.1
	Melinex	8.9
	Mica	7.8
	CR-39	10.3
^{4}He and ^{7}Li from $^{10}B(n,^{4}He)^{7}Li$ reaction	LR-115	3.45
	CA 80-15	2.25
	Daicel	2.20
^{4}He from Uranium (~ 4.75 MeV)	LR-115	4.15
	CA 80-15	5.10
	Daicel	3.40
	CR-39	4.38
^{4}He from Plutonium (~ 5.16 MeV)	LR-115	5.16
	CA 80-15	5.71
	Daicel	2.65
^{4}He from Americium (~ 5.48 MeV)	LR-115	3.59
	CA 80-15	4.48
	Daicel	3.09

* The overall uncertainties on these values were estimated to be 3-5 % [5]

is related to the concentration, C (g cm^{-3}), of the element by the equation :

$$T_d = K_{wet} \frac{CXN}{A} \sigma\phi t$$

K_{wet} is defined as the track registration efficiency in solution and is expressed in cm. The values of track registration efficiency in solution medium, of some of the most commonly used detectors are given in the Table-5. The flexibility and ease of the sample preparation, uniform track distribution in the detector with the consequent need for scanning only a small representative area, are some of the special features of track registration from solution medium which are especially useful for analytical applications. The disadvantage of recording tracks from solution medium is low track registration efficiency. The optimum times of etching of some track detectors are given in Table-6 which were obtained by following the change in the track density as a function of the etching time. The method of K_{wet} has been currently employed in our Laboratory for the

Table – 6 : Etching conditions of some common track detectors when tracks are registered from solution medium

Charged Particle	Detector	Etchant	Temperature (° C)	Time of etching (Minutes)*
Fission fragment from ^{235}U fission	Lexan Makrofol Melinex Mica	6 N NaOH 6 N NaOH 6 N NaOH 40 % HF	60 60 60 22	60 (60) 60 (60) 60 (60) 30 (30)
^{4}He and ^{7}Li from $^{10}B(n,^{4}He)^{7}Li$ reaction	LR-115 CA 80-15 Daicel	2.5 N NaOH 2.5 N NaOH 2.5 N NaOH	60 60 50	90 35 25
^{4}He from Uranium (~ 4.75 MeV)	LR-115 CA 80-15 Daicel	2.5 N NaOH 2.5 N NaOH 2.5 N NaOH	60 60 50	40(130) 40(120) 30(110)
^{4}He from Plutonium (~ 5.16 MeV)	LR-115 CA 80-15 Daicel	2.5 N NaOH 2.5 N NaOH 2.5 N NaOH	60 60 50	55(120) 55(120) 35(150)
^{4}He from Americium (~ 5.48 MeV)	LR-115 CA 80-15 Daicel	2.5 N NaOH 2.5 N NaOH 2.5 N NaOH	60 60 50	75 75 70(160)

*Number in parenthesis is the optimum etching time when the tracks are recorded from dry planchetted source.

assay of trace uranium in soil and leaf samples from different locations across the country and the method of K_{dry} for the trace level estimation of Pu in bioassay samples. The details of some of the studies are given below.

Application of SSNTDs

Uranium exploration (TEFUREX) using solid state track detectors

Uranium and thorium are radioactive elements and this property assists in their location and evaluation by methods based on measurement of radioactivity. Among the radioactive decay products of uranium is a noble gas radon (^{222}Rn) which can diffuse or be transported to some distance through fissures in the rock structure and find its way into the soil and surrounding material. Therefore, radon measurement is most promising method for detecting uranium deposits (buried too deep) to be located by any conventional method. A technique based on the registration of alpha tracks from ^{222}Rn on alpha sensitive track detector was developed for uranium exploration [7]. The detector is exposed to the soil gas for known length of time. The ^{222}Rn alpha tracks are registered on the detector. The alpha track density gives a measure of ^{222}Rn concentration in the soil. This technique was developed in Radiochemistry Division and field tested in areas of known uranium occurrences jointly with Atomic Mineral Division. As it is a very simple technique, it can be implemented easily for field studies.

Quantitative determination of uranium in soil and leaf samples by fission track method

Uranium, thorium and their daughter products are significant sources of natural radioactivity in the environment. Human population is always exposed to ionizing radiations from natural sources present in earth's crust. Natural uranium has higher abundance in earth crust than other toxic elements such as Sb, Cd, Bi, Hg, etc. Concentration of uranium however varies from

region to region depending upon the geology of the area.

Fission track method has been widely used for the determination of U in soils during the last two decades [8-11]. Most of the workers have used the dry external detector method for the estimation. However, in this method, the distribution of the tracks over the surface of the detector is not uniform.

Hence, for any quantitative determination, it is essential to count the total number of tracks over the entire detector area which is time consuming and tedious. All these problems can be reduced if the tracks are recorded from the solution medium. Homogeneous track distribution in solution samples is obtained by immersing the detectors in the solution and then irradiating them with thermal neutrons. Trace uranium in soils of Bihar and Goa have been measured using this method. The samples were irradiated in D8 position of APSARA reactor. The reactor neutron spectra have both thermal and fast neutron components. Hence in a reactor irradiation, the contribution from the fast neutron induced fission of ^{232}Th present in soil samples becomes significant. Therefore, corrections have been applied to the uranium data in the present work due to the fast neutron fission of ^{232}Th. Earlier workers have not applied these types of corrections while estimating uranium in soils by fission track method. The present data obtained for soil samples from Bihar region have also been compared with the data existing in the literature for soil samples of other Indian States.

A known amount of soil sample was taken for the analysis. The samples were leached with ~2M nitric acid. Samples of about 200 microlitres along with a lexan detector strip sealed in polypropylene tubes were irradiated with neutrons in D-8 position of APSARA reactor for 1 hr. The irradiations were done with and without covering the samples with 1 mm thick cadmium wrapper. The 1 mm thick cadmium cover cuts off the thermal component of the reactor spectra and hence in that irradiation condition, we get the fast fission contributions of ^{238}U and ^{232}Th only. Uranium standards of different concentrations were also irradiated simultaneously. After the irradiation, the track detector strips were chemically etched in 6M NaOH at 60^0 C for 1 hr and the fission track density measured using an optical microscope. Six samples were analysed for their uranium content. The blank correction and corrections due to fast neutron fission from ^{232}Th were also applied to the fission track densities. The blank corrections were estimated by irradiating the detectors in 2M HNO_3 solution along with samples. The fast neutron fission corrections were estimated from the track density data obtained from the samples irradiated with cadmium wrappers. The uranium contents were estimated by comparing the track densities of detectors immersed in sample and the standard uranium solutions irradiated along with the samples under the same irradiation conditions. The data are presented in Table-7. Similar technique has been used for the estimation of uranium in leaf samples and the results are given in Table-8. A comparative study [12] of isotope mass spectrometry and fission track analysis for the determination of nanogram levels of uranium has shown the precision and accuracy of the fission track method as $\pm$3.3 % as compared to $\pm$ 0.52% for mass spectrometry.

Table – 7 : Estimation of Uranium in soil samples of Bihar by fission track method

Nature of the sample	U content estimated (ng/g of soil)
Soil Dust	749.59 $\pm$ 61.50
Sand	162.88 $\pm$ 10.10
Stone dust	218.98 $\pm$ 11.00
Brick Powder	419.63 $\pm$ 19.00
Coal powder	998.70 $\pm$ 70.00
Cement	107.11 $\pm$ 16.10

Table – 8 :Uranium estimation in some leaf samples of Rajmahal area of Jharkhand

Nature of sample	Uranium (ng/gm)
Guava leaf	337 ± 37
Jack fruit	75 ± 25
Oleander leaf	103 ± 30
Black berry	72 ± 18

Estimation of trace levels of Pu in bio-assay samples by fission track technique

Trace level estimation of plutonium in urine samples of personnel working in nuclear installations has to be routinely carried out. The method involves the separation of trace plutonium from bulk urine sample, electrodeposition of plutonium on a suitable backing and estimation of plutonium by alpha spectrometry. This technique has a sensitivity of 0.5 - 1.0 mBq level estimation of plutonium. In order to comply with the recent ICRP-78 recommendations [13], the detection limits has to be 0.34 mBq for class M type plutonium compounds and 0.038 mBq for class S type plutonium compounds. There is a need, therefore, to have a method to estimate plutonium at ultra trace levels. We have developed and standardised a method based on fission track registration in Solid State Track Detector (SSNTDs) for the estimation of ultra trace levels of plutonium. Plutonium is separated from the bulk sample using the anion exchange separation technique. The separated plutonium is electrodeposited on a stainless steel planchet. The plutonium sample is covered with Lexan solid state track detector and irradiated with neutrons in APSARA reactor for 2 to 4 hrs. A standard plutonium sample of identical isotopic composition covered with Lexan solid state track detector is also irradiated along with the sample. After irradiation, the lexan foil is chemically etched and the developed fission tracks are counted manually under an optical microscope. The track density in the Lexan foil of the sample and of the standard is used to calculate the concentration of plutonium in the sample. The results are shown in Table-10. The preliminary results show that one can estimate ~ 0.1 mBq levels of plutonium in the samples by this method with a precision of about $\pm$ 35%. This method requires a quantitative separation of plutonium from the trace amount of uranium present in the sample. The error in estimation of Pu due to the presence of uranium can also be reduced to a great extent by using an irradiation position having predominantly large thermal neutron contribution. The sensitivity of the technique depends on the background tracks due to the chemicals and the backing materials. By using ultra pure reagents, minimum detection limit (MDL) of about 50 micro Bq as required by ICRP-78 for the estimation of Pu can be achieved.

Application of SSNTDs in neutron dosimetry

The neutron dosimetry with SSNTD has been rapidly progressing since the development of CR-39 plastic. Its attractive features of proton registration, insensitivity to photons and small size allows its application to personal neutron dose monitoring in mixed radiation field. Recoil and (n,α) reactions can be used for neutron dosimetry using CR-39. It is considered to serve as one of the promising detectors in neutron fields when existing counters do not meet the requirements. Neutron field appearing in laser induced fusion process, where fission neutrons scattered in a small fuel target would be emitted as a single pulse of few hundred pico seconds, could be measured by CR-39. Many kinds of SSNTD have been developed for neutron dosimetry. The neutron dose equivalent is measured by counting the number of tracks per unit area on the detector surface caused by the heavy charged particle produced by neutron through fission, scattering, (n,α) and other reactions. Proton recoil measurement using CR-39 is being routinely used for neutron dosimetry. A low neutron flux measurement by SSNTD is an emerging field.

Application of SSNTDs for very low level alpha estimation in waste streams

The effective management of radioactive waste solutions requires the alpha activity levels to be less than 0.037Bq/ml of the waste solution. The assay of radioactivity in the waste solution is presently being carried out by direct alpha counting of a dried solution of the waste. The minimum detection limit of this method is limited to a few Bq levels. A technique based on the alpha track registration on SSNTDs is being developed to directly assay the alpha activity in waste solution. To start with, CR-39 track detectors were exposed for known times to the actinides solutions of known alpha activities. The actinides used were Th and Am. The tracks registered on exposing the detectors directly for known time in the solution of actinide isotope were related to the gross alpha activity. The measured activity values (26.0-29.0Bq /ml) were found to be comparable to the values determined by using ZnS detector. The MDL of this method which was calculated from the number of tracks recorded from the blank (2M HNO_3) is about 1 Bq/ml for an exposure time of 8 days [14]. MDL can be lowered further to mBq if the solutions are evaporated on the planchet and the tracks are recorded in the dry medium. Experiments in this direction are in progress.

Measurements of alpha to spontaneous fission ratios of heavy actinides by SSNTDs

Alpha to spontaneous fission ratios of ^{252}Cf, ^{244}Cm, ^{238}Pu and ^{240}Pu have been determined by solid state nuclear track detectors [6,15]. These ratios are useful for measuring the partial half- life and for the identification of these actinides in trace levels. For measuring these ratios, the track detectors such as Lexan, Tuffak, CR-39 and LR-115 were exposed to these actinides to record alpha and spontaneous fission tracks and the ratios were calculated from the alpha and the fission track densities. The measured values of alpha to fission ratios were found to be 31.56 ± 0.35, $(6.977\pm0.014)\ 10^5$, $(5.383\pm0.288)\ 10^8$ and $(1.688\pm0.153)\ 10^7$ respectively for ^{252}Cf, ^{244}Cm, ^{238}Pu and ^{240}Pu respectively These ratios are found to agree well with the expected values.

Determination of trace levels of U in Andaman & Nicobar seawaters employing Solid State Track Detectors

Seawater is being looked upon to meet the future demands of energy in view of the enormous amount of uranium locked in there by scientists in USA, Japan, Korea and India. As such, the global average is reported to be 3.3 ppb by oceanologists, but there are local variations in the uranium concentration due to the surrounding land topography, rainfall and other meteorological conditions coupled with the influence of river discharges in the vicinity, oceanic currents in the region and marine bottom volcanic activity. It is important to know the precise concentration of U in seawater for siting an optimum location for harvesting uranium from seawater.

Solid State Track Detector technique has been employed at Radiochemistry Division for the determination of uranium in sea water [16]. Several uranium standard samples were prepared in the range of U conc. 2 ppb to 15 ppb. The Lexan pieces were used as nuclear track detectors for the registration of fission fragment tracks. These detectors were washed thoroughly and dried. These cleaned pieces were then used to make the “sandwiches” of known weight of dried drops of samples of seawater and uranium standards. These sandwiches were prepared for each seawater sample and also for uranium standards of known U concentration. The samples were then irradiated with neutrons at the E-8 position of Apsara Reactor for 2 hours. After the irradiation, the Lexan detectors were etched with 6 N NaOH at 60^oC for 60 min and the tracks were counted under an optical microscope. The trace quantity of uranium content in seawater for each sample is calculated from the fission track density in comparison to uranium standards. The

uranium content in the seawater is found to be in the range of 2.0 to 3.3 ppb. Major advantage of this method is that the preparation of the samples does not require a chemical separation or any other purification, which is a pre-requisite in most of the physico-chemical methods like fluorimetry, spectrophotometry and voltametry.

References

1. R.L. Fleischer, P.B. Price and R.M. Walker, Nuclear Tracks in Solids : 'Principles and Applications' (Berkeley: Univ. of California Press) 1975.
2. R. H. Iyer. J. Chemical education, 49 (1972) 742.
3. A.K.Padey, R.C.Sharma, P.C.Kalsi and R.H.Iyer, Excitation function and fragment angular distribution in the fission of ^{197}Au induced by ^{4}He ions in the energy range 30-70 MeV. Paper presented in 7th National conference on Particle tracks in solids, Jodhpur, India (1977).
4. G.A. Wagner, Archaeological applications of fission track dating, Nuclear Tracks Detection Vol2. No.1 51-64 (1978)
5. R. H. Iyer and N.K. Chaudhury, Radiation Measurements, 27 (1997) 529.
6. P. C. Kalsi, J.Radioanal. Nucl. Chem., 242(1999) 169.
7. R.H.Iyer, Simpler process for uranium exploration and recovery, Science Today, 37 (1977).
8. R. Azam and R. Prasad. J. Radioanal.Nucl. Chem., 133 (1989) 199.
9. P.J. Jojo. Ashavani Kumar and Rajendra Prasad , Proc. Seventh National Conf. on Particle tracks in solids, Eds. S. Kumar and A. R. Reddy, Jodhpur, 1991, p 93.
10. Parduman Singh Kanwar, B. S. Bajwa and Surinder Singh, Proc. X National Symp. on solid state nuclear track detectors, Ed. Shyam Kumar, Kurukshetra, 1996, p. 39.
11. Sarita Mittal, S. S. Bhatti, A.S. Jodha. S. Saravanan, Deepak Gopalani, S. Kumar and P. C. Kalsi, Proc. XI National Symp. on SSNTDs and applications, Ed. Surinder Singh, Amritsar, 1998, p. 307.
12. L. P. Geraldo, M. F. Cesar, O. Y. Mafra and E. M. Tanaka, J. Radioanal. Chem., 49, (1979) 115
13. ICRP-78 (1997). Individual monitoring for internal exposure of workers. Replacement of ICRP publication 54. Annals of the ICRP Pergamon Press, 1998.
14. P.C. Kalsi, A. Ramaswami and V. K. Manchanda (unpublished work).
15. P. C. Kalsi, R. C. Sharma, A. K. Pandey and R. H. Iyer, Nuclear Instruments and Methods, 82B (1993) 151.
16. P. C. Kalsi, A. Ramaswami, A. K. Saxena and V. K. Manchanda Determination of trace levels of U in Andaman & Nicobar Sea waters employing Solid State Nuclear Track Detectors, Paper presented in the Nuclear and Radiochemistry Symposium, (NUCAR2005) Guru Nanak Dev University, Amritsar, India March. 15-18 (2005).

SYNCHROSCOPE FOR NUCLEAR POWER PLANT TRAINING SIMULATOR

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Introduction

The synchroscope, being one of the important aids to the plant operator in the main control room, needs to be simulated with a perfect replica as far as its design in general and front appearance in particular are concerned. A synchronising unit consisting of a synchroscope, a double frequency meter and a double voltmeter, is one of the devices mounted on

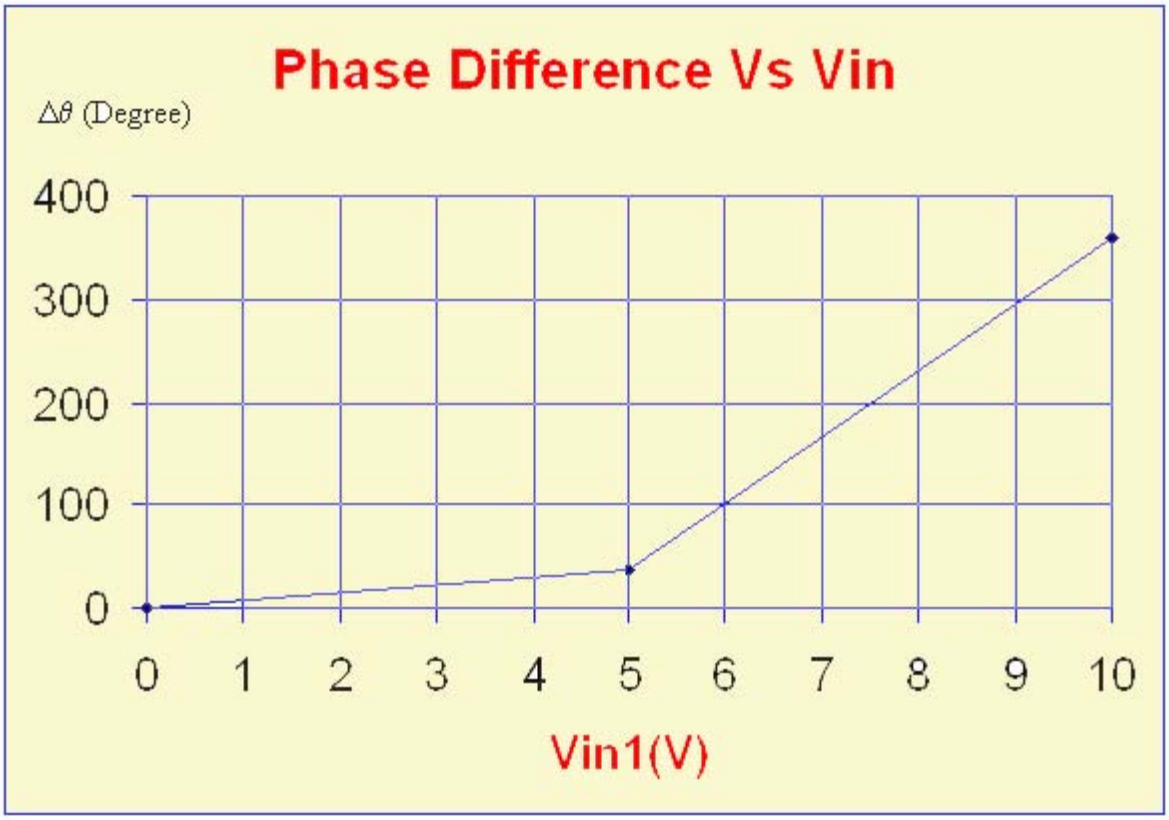

Fig. 1 Phase difference Vs Analog input

control room panels. The synchroscope is simulated using a stepper motor driving a pointer. Microstepping drive is used to ensure smooth operation of the synchroscope even at low speeds, to give realistic feeling of synchronisation process to the operator under training.

Simulated Synchronising Unit

The synchronising unit is used to monitor phase difference, frequency difference and voltages of the 2 AC voltages that are being synchronized. It consists of synchroscope, double frequency meter and double voltmeter.

Synchroscope

The synchroscope is used to monitor synchronism of two alternating voltages, one of the plant synchronous generator and the other of the electric grid. It indicates the magnitude of their phase difference when their frequencies are equal. It also gives a measure of the sign and magnitude of the difference between their frequencies by direction and speed of rotation of its pointer.

The simulator synchroscope consists of:

a) Stepper motor driven synchroscope facia

b) Driver unit for above stepper motor

Stepper motor driven synchroscope facia : This is a part of the synchroscope unit. The synchroscope unit consists of above synchroscope, double voltmeter and double frequency meter.

Drive unit for stepper motor : Drive unit is microcomputer control system driving needle of synchroscope based on micro-mini stepping drive. This is a special drive designed to move a stepper motor in steps less than its natural full or half step, thereby, giving a real feeling of actual synchroscope while attaining power plant generator frequency synchronisation.

As per the specification, the simulator control system has 2 analog inputs and 2 digital inputs. It gives two drive outputs for driving two stepper

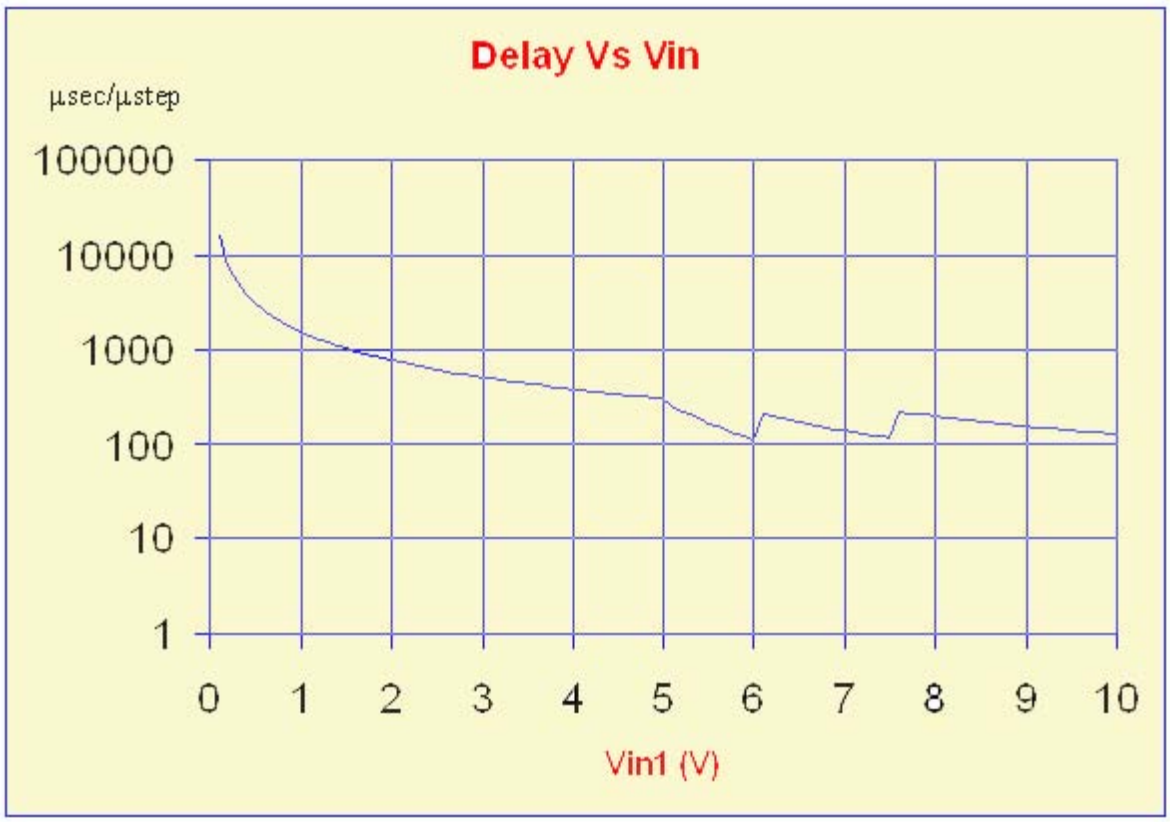

Fig 2 Delay between µstep Vs Analog input

motors in MINI/MICRO stepping mode (Refer *BARC Newsletter* No.251,December 2004 issue).

First analog input gives phase difference between 2 AC's, $\triangle\theta$ information. This is scanned every 200 msec. Both the motors are rotated by $\triangle\theta$ angle in 200msec, till next scan is done. Fig 1 shows $\triangle\theta$ Vs analog input relation. The second analog input gives direction information. For input less than 4V, the motor is standstill; between 4V and 7V, motor is rotated in clockwise direction; and for between 7V and 10V, motor is rotated in anticlockwise direction; i.e., 0-4 V : Needle standstill, 4-7 V: Rotates clockwise, 7-10 V: Rotates anticlockwise.

First digital input when active low moves the motor No.1 in clockwise direction at fixed speed. This input overrides the analog input and is used to position the synchroscope pointer to a desired position. The second digital input does the same for motor No. 2.

Analog inputs are scanned at every 200 msec and the speed of the pointer is determined as $\triangle\theta$/200msec. The motor is rotated at this speed with 32 micro steps per full step for 200 msec, till the next scan is done. The direction of movement is controlled by the second analog input.

The system is designed based on hardware developed in RR&PS Section of RCnD. The main CPU board is 8086/87 processor-based. The MICRO stepping drive board is 8751-based slave board. The ADC card uses SAR type ADC with 12-bit resolution, can take 32-channel, and belongs to the standard EC-BUS board family (Refer *BARC Newsletter* No. 202 - November 2000 issue).

Improvements

When Vin1 > 6 V, speed governing delay saturates. Hence, for Vin1 > 6 V motor drive is at 16 micro step mode and for Vin1 > 7.5 V, its drive is at 8 micro step. This improves the speed limit at higher error voltages.

Delay computation

Case 1: Input 0-5 V, 32 μstepping mode

Speed = 36Vin1°/sec = 640 Vin1 μstep/sec

Delay = 1562.5/Vin1 μsec/μstep

Case 2: Input 5-6 V, 32 μstepping mode

Speed = (324Vin1-1440) °/sec

Delay = 56249.3/(324Vin1-1440) μsec/μstep

Case 3 : Input 6-7.5 V, 16 μstepping mode

Speed = (324Vin1-1440) °/sec

Delay = 112500/(324Vin1-1440) μsec/μstep

Case 4: Input 7.5-10 V, 8 μstepping mode

Speed = (324Vin1-1440) °/sec

Delay = 225000/(324Vin1-1440) μsec/μstep

Microstepping Technology for Stepper Motor

Normal two-phase 50 pole stepper motors have rotational (rotor) least count of 1.8°. By this indigenous method, we have achieved the rotor angular control up to 0.018°, i.e., one by hundredth of the natural least count. This indigenous technique is having copyright (Indian patent office ref no. L-17595/98), and now can be obtained locally, as BARC has transferred the know-how to private entrepreneurs.

Conclusion

The synchroscope has been successfully integrated in Kaiga-1 simulator and technologically demonstrated. This unit is improved upon the normal stepper motor driven synchroscope in RAPP 1 & 2 simulator. Also, it does not require high voltages 2 phase synchronous motors employed by imported simulators. For TAPP 3&4 540 MW simulator, NPCIL is using the same micro-stepping concept but getting the units fabricated from Indian private entrepreneurs. Technology of micro stepping has been handed over to private entrepreneurs by BARC. This method has been appreciated by Australian power plant Simulator Company, delivering the software packages to NPCIL simulator.

NATIONAL SCIENCE DAY

National Science Day is celebrated every year on 28th February to mark the invention of 'Raman's Effect'. BARC celebrated National Science Day on the theme "Celebration of Physics".

Dr S. Banerjee, Director, BARC, delivering the inaugural address on the occasion of National Science Day celebration at BARC.

As a part of celebrations during the month preceding National Science Day, special public awareness programmes were organised for the police officials, viz., 'The Scientists-Police Meet' at Kolhahpur on February 4, 2005. Dr S.P. Kale from NABTD, BARC, delivered a lecture on 'Peaceful Uses of Atomic Energy with special reference to DNA Fingerprinting & Forensics Sciences'. Mr R.K. Sharma, Head, Media Relations & Public Awareness, SIRD, BARC, delivered a lecture on BARC's technologies for better quality of life and isotopes

Group of students from the Dhirubhai Ambani Institute of Information and Communication Technology (DA-IICT) and K.B. Institute of Pharmaceutical Education and Research, Gandhinagar, seen at the Faculty-Students-Scientists Meet

in healthcare and industry. On February 5, 2005, 'The Students-Scientists Meet' programme was organised at the Department of Physics, Shivaji University, Kolhapur. About 350 M.Sc. students from the university participated in the programme. Dr S.P. Kale interacted with the students with special reference to the opportunities in BARC with regard to the basic research in various fields. Mr R.K. Sharma, talked about the BARC's technologies for better quality of life.

Similarly, at Dhirubhai Ambani Institute of Information and Communication Technololgy (DA-IICT) and K.B. Institute of Pharmaceutical Education and Research, Gandhinagar, a Faculty-Students-Scientists Meet for their students and faculty members were organised during February 18-19, 2005.

Dr A. Ramaswami, RCD, BARC, spoke on 'Radioactivity and Power Reactors,' Dr Veena Sagar, FCD, BARC, demonstrated experiments on radioactivity measurements, Mr M. Srivastava, FTD, BARC, gave a talk on 'Advancements in Nuclear Agriculture,' Mr Kislay Bhat, Computer Division, BARC, spoke on ANUPAM Super Computers, and Mr R.K. Sharma spoke on 'Radioisotopes in Health Care & Industry, and Spin-off Technologies of BARC.' Dr S.K. Nema from Institute of Plasma Research, Ahmedabad, gave a talk on Plasma Pyrolysis System.

In addition, during the previous month, around 300 students and the teachers from AEC Jr. College visited BARC.

On the day of National Science Day, a programme specially designed for the event was held. Over 200 science students from ten local colleges, accompanied by their professors, were invited to participate. The main programme was organised at Central Complex Auditorium, BARC, and was inaugurated by Dr S. Banerjee, Director, BARC. Dr Banerjee underlined the role that nuclear power would play in the energy scenario of India.

Specially prepared popular talks were delivered on this occasion on 'Neutron as a Probe' (Dr S.L. Chaplot), 'Potention of Synchrotron Radiation' (Dr S.M. Sharma) and 'Nuclear Power for Energy Security' (Mr U.D. Malshe). The students were taken around the 100 MWe DHRUVA Research Reactor and Food Technology Division. Mr R.K. Sharma, Head, MR&PA, SIRD, welcomed the participants and introduced the speakers to the participants. Dr J.V. Yakhmi, Head of TPPED, BARC, in his introductory remarks, highlighted the work published on Albert Einstein one hundred years ago in 1905.

FOURTH DAE-BRNS NATIONAL LASER SYMPOSIUM

The fourth DAE-BRNS National Laser Symposium (NLS) was held during January 10-13, 2005 at Anushaktinagar, Mumbai. Dr S. Banerjee, Director, BARC, in his inaugural speech pointed out the significance of laser science and technology in various national programmes. His particular emphasis was on the applications in Nuclear Science and Technology. He elaborated in detail on how lasers have influenced materials science. The Chief Guest, Dr D.D. Bhawalkar, enumerated the progress of laser research in the country during the last three decades and also dwelt upon future potentialities. Conveners Dr B. M. Suri and Dr V. K. Mago, in their welcome addresses, brought out the challenges and opportunities facing the laser community in the country. Dr Alok K. Ray, Secretary of the symposium, conveyed the gratitude of laser community to DAE-BRNS for supporting NLS actively.

The focal theme of the NLS was "Lasers in Nuclear Science & Technology". The topics ranged from 'physics and technology of lasers' to 'quantum optics'. About 320 contributory papers, 27 invited talks by national and international scientists and 14 theses were presented. In all, more than 550 delegates participated. Two short courses were organised in collaboration with 'Indian Laser Association' at Homi Bhabha Centre for Science Education. Dr R. R. Puri and Dr M. S. Bhatia convened the courses on 'Atom Optics' and 'Laser Based Instrumentation', which benefitted more than 65 students from all over the country. An exhibition of local and international industrial products related to laser systems was also organised on this occasion.

Dr S. Banerjee, Director,BARC, inaugurating the fourth DAE-BRNS National Laser Symposium

SEMINAR ON "ECIL INSTRUMENTS FOR NUCLEAR APPLICATIONS (ECIL-INA 2005)"

A half-day seminar on February 15, 2005, was organised at BARC, on "ECIL Instruments for Nuclear Applications (ECIL-INA 2005)" by the Centre for Equipment Electronics & Management (CEEM) in collaboration with M/s. Electronics Corporation of India Limited (ECIL). The aim of the seminar was to interact with the BARC user community of ECIL instruments/modules to meet the following objectives :

- to highlight the new technical developments about the latest products of ECIL in the field of nuclear instrumentation.
- to gather information about the requirements of ECIL instrumentation modules at BARC and to replenish and maintain the BARC-ECIL Module Bank.
- to obtain a feedback of the electronic services for the ECIL instruments modules at BARC, and
- to discuss suggestions for further improvements in product design, and quality services.

Mr Jagmohan Singh, Head, CEEM, BARC, welcomed the delegates and highlighted the seminar objectives. The seminar was inaugurated by Mr G. Govindarajan, Director, A&MG and E&IG, BARC, and was attended by about 65 persons from different Divisions of BARC. Mr Govindarajan reviewed the important role of ECIL products in use at BARC. He noted that the electronics services for repairs and upkeep of ECIL instruments have been organised by CEEM, BARC in association with ECIL and felt that these should be useful for improving the confidence of user community at BARC in ECIL products. Mr Umapathy, Senior DGM, ISD, ECIL, Hyderabad, described the ECIL modules and instruments already in use. Mr K.N. Murthy, Senior Manager, ISD, ECIL, Hyderabad, focused on new developments in the ECIL modules and gave a brief summary on the advancements therein.

Mr G. Govindarajan, Director, Automation & Manufacturing Group and Electronics & Instrumentation Group, BARC, inaugurating the seminar

During an interactive feedback session, the queries of several users were attended to by Dr M.S.R. Murthy & others. Mr Naronha elaborated the concept of BARC-ECIL Module Bank for the benefit of the users of nuclear instruments at BARC. Mr Jagmohan Singh informed that this Module Bank will be activated and maintained by CEEM soon. Dr S.K. Kataria, Associate Director, E&I Group (E), BARC, gave several suggestions. He advised ECIL to give special attention to quality control and testing of the products before they are dispatched. Participants gave their suggestions/ comments about electronics services for ECIL instruments/modules and about the possibility of providing these services for similar instruments from other suppliers. Requirements of the instruments from ECIL for 2004-05 and 2005-06 were also compiled along with suggestions for improvements in quality and for new products.

14TH TRAINING WORKSHOP ON "PLANNING, PREPAREDNESS AND RESPONSE TO RADIOLOGICAL EMERGENCIES"

BARC and NPCIL have been jointly conducting Training Workshops on "Planning, Preparedness and Response to Radiological Emergencies" for DAE officials since 1991 at various Nuclear Power Plant sites. The objective of this training programme is essentially to streamline and standardise the emergency response procedures; adopting the state-of-the-art technology and bring up DAE's emergency response plans in line with international standards.

Mr H.S. Kushwaha, Director, Health, Safety & Environment Group, BARC, inaugurating the training workshop. (Also present from left to right are : Mr S. Sukumar, Training Suptdt., KGS, Mr Harsh Kapur, PD, KGS 3&4, Mr K. Ramamurthy, SD, KGS 3&4, Mr G.Nageshwar Rao, SD, KGS 1&2 and Mr V.V. Sanath Kumar,CS, KGS 1&2

Participants of the Training Workshop with the faculty and dignitaries

The 14th training workshop in this series was held at Kaiga Generating Station (KGS), Kaiga, during March 7-11, 2005. A total of 32 officers in the grade of Shift Charge Engineer/ Asst. Shift Charge Engineer, Senior Officers from Health Physics Units/ESLs from various Nuclear Power Stations, Research Reactors, Reprocessing Plants and IGCAR participated in this workshop. The faculty consisted of senior officers from BARC, NPCIL and AERB.

This training programme was formally inaugurated on March 7, 2005 at KGS auditorium. Mr H.S. Kushwaha, Director, HS&EG, BARC, Mr G. Nageshwar Rao, SD, KGS 1&2, Mr K. Ramamurthy, SD, KGS 3&4, Mr Harsh Kapur, PD, KGS 3&4, Mr V.V. Sanath Kumar, CS, KGS 1&2 and Mr S. Sukumar, Training Suptdt., KGS, were the dignitaries present. Mr K. Narayanan Kutty, Member Secretary, Organising Committee, gave a brief outline of the structure and contents of the course. He emphasised on the importance being given to the practical aspects like Desk-top exercises and deliberations among the participants on the experience gained in conducting emergency response exercises at various sites. He also informed the august gathering that so far 328 senior officers had participated in the training workshops held at different sites.

In his keynote address, Mr H.S. Kushwaha, Director, appreciated the fact that emergency response exercises were regularly conducted at all centers and that the procedures were updated periodically. He stressed on standardising the procedures so that any confusion and panic could be avoided in case of an event leading to an emergency situation. He reminded the participants that the goals of emergency response system should include strategies to regain control of the situation, to prevent or mitigate the consequences at the site, to prevent the occurrence of deterministic effects to the workers and to limit stochastic effects to the general members of the public to the minimum. Consequently, it should be the endeavour of all concerned to evolve an integrated response system in which the responsibilities and authorities are clearly defined and coordinated. One of the most important aspects of managing a radiological emergency is the ability to promptly

and adequately determine and take actions to protect the first responders and members of the public. This assessment must take account of all critical information available at any time and must be a dynamic process being periodically reviewed and updated based on more detailed and complete information which may become available. In this context, he informed the audience that HS&EG, BARC, is in the process of finalising an Indian Real Time On-line Decision Support System for Off-site Nuclear Emergency which will help the decision-makers for getting fast information on radiation levels and meteorological data which are essential for planning any counter-measures.

The Training Course was formally inaugurated by Mr G. Nageshar Rao, SD, KGS. In his address, he expressed happiness that KGS had been selected as the venue for the present course and reminded the participants of the necessity of remaining ever alert towards any off-normal incidents and to keep the emergency response system updated. He also emphasised on the importance of remaining alert to incidents of fire which can also lead to an emergency.

The 5-day Workshop consisted of lectures, desk-top exercises and technical visits.

Following Invited talks on the following were also delivered :

1. 'Chernobyl accident - lessons learnt and its relevance to our emergency preparedness programme' by Mr S.A. Sukheswalla, AERB
2. 'Emergency operating procedures for Indian PHWRs' by Mr G. Nageswar Rao, SD, KGS
3. 'Human behavioral aspects during emergencies' by Mr A.K. Sharma, DCE (MPD), NPCIL
4. 'An overview of the Nuclear / Radiation Emergency Response System in India' by Mr K. Muralidhar, Secretary, AEC & Member Secretary, CMG
5. 'Inherent & engineered safety features of future generation plants' by Mr S.A. Bhardwaj, Sr. ED (Eng.), NPCIL

In order to have a feel of practically handling real emergency situations, following Desk-top Exercises were conducted :

1. 'Radiological Emergency during a transport accident involving radioactive material' by Dr S.P. Agarwal and others.
2. 'On-Site and Off-Site Emergency at NPP sites – response and counter measures' by Mr B. Ramamirtham and others.

The salient feature of the course was the three sessions devoted exclusively for presentations by the participants to brief the emergency planning and response system at different sites and to discuss the experience gained in conducting the off-site and on-site emergency exercises at different sites.

The training course concluded with the valedictory function held on March 11, 2005. Mr S.A. Bhardwaj graced the occasion as Chief Guest. Mr G. Nageshwar Rao, Mr K. Ramamurthy, Mr Sanath Kumar, Mr K. Muralidhar, and Mr S. Sukumar were the dignitaries present. Senior officers of KGS also attended the function.

Mr S.A. Bhardwaj, presented certificates to all the participants. An important item of the function was a detailed presentation by Mr S.A. Bhardwaj on the 'Inherent & Engineered Safety Features of AHWR and 700MW PHWRs designed by NPCIL'. The lecture was followed by a session for detailed technical discussion on the subject.

DAE-BRNS SYMPOSIUM ON "ELECTRON BEAM TECHNOLOGY AND APPLICATIONS"

Electron Beam (EB) Technology, at present, finds wide applications not only in nuclear, aerospace and defense-related industries but also in conventional engineering practice. Electron Beam technologies have distinguished

themselves in terms of compactness, process efficiency, eco-conservation, techno-economics, and innovative possibilities. As we advance into the new technology era, there is a need for evolving strategies to apply the EB technology to a large number of industrial sectors. The number of users of EB machines is steadily increasing throughout the country. In recent years, the use of electron beams is becoming common practice to develop novel materials, to increase specific yields and to improve the all-round products quality. BARC has a long tradition in the design and development of electron beam machines and processes for thermal and non-thermal applications. Apart from developing high power beams for thermal applications, BARC is currently involved in establishing an Electron Beam Centre for radiation processing of various materials.

The DAE-BRNS Symposium (SEBTA-2005) will be held at the Multipurpose Hall of BARC Training School Hostel at Anushaktinagar, Mumbai, during September 28-30, 2005, in association with the Power Beam Society of India (PSI).

The symposium will provide an opportunity for active researchers, scientists and industries to review the current scenario, to share the available expertise and to consider directions for future development. There will be review and invited talks by eminent engineers and scientists with long years of practical experience in this field.

Major themes to be covered are :

- Overview of EB Technology in India
- EB systems for thermal and non-thermal processing of materials
- Beam characterisation
- Beam and processing modelling
- Physical processes during EB welding, melting and evaporation
- EB irradiation for polymers, medical sterilisation, etc.
- Instrumentation related to monitoring, control and diagnostics
- High voltage DC and pulsed power sources
- Maintenance and trouble shooting of EB equipment

For further details, contact :

CALL FOR NOMINATIONS FOR INS AWARDS – 2004

Indian Nuclear Society (INS) invites nominations for the INS Awards – 2004 from the following ;

a) Heads of Academic or Industrial Organisations having significant activities in the Technology field or related areas.

b) Present or Past members of the Board of Trustees of Indian Nuclear Society.

c) Emeritus Members of the Indian Nuclear Society.

d) Present and Past Presidents of the Indian Nuclear Society.

Seven copies of the duly prepared nominations, individually in full form as per the Performa (downloadable from the website) and a soft copy (optional), are to be sent in a sealed cover and by registered post/courier to Mr G.D. Mittal, Hon. Secretary, Indian Nuclear Society, Project Square, Anushaktinagar, Mumbai 400 094. The last date for the receipt of the nominations is **July 11, 2005.** For further details, please visit INS Website:
http://www.indian-nuclear-society.org.in
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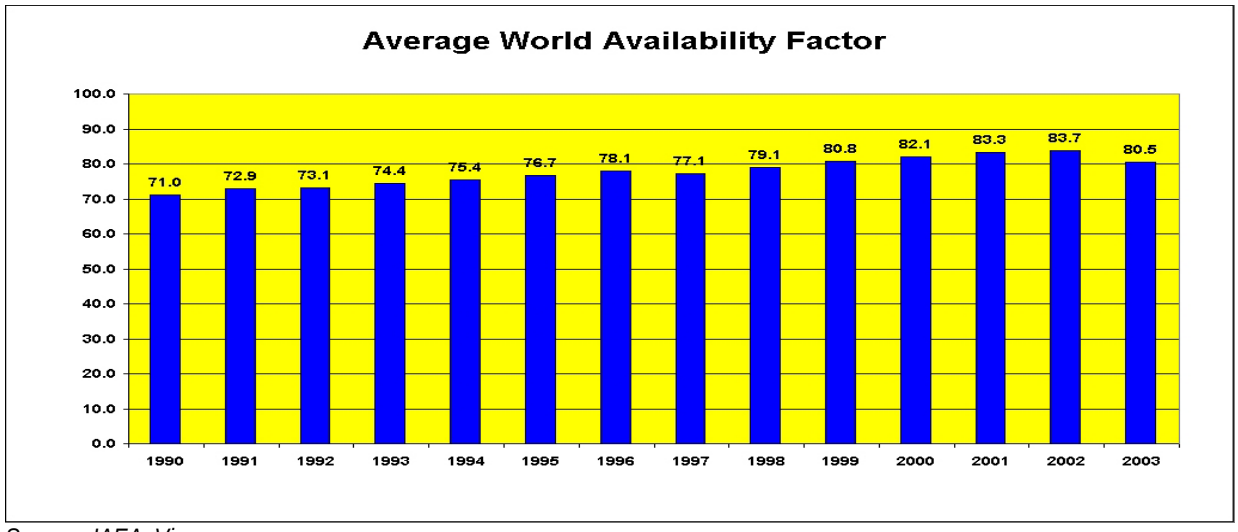
WORLD NUCLEAR POWER SCENARIO

Presently 31 countries in the world produce electricity from 440 nuclear power stations with a total installed capacity of 3,66,913 MW(e). 25 more nuclear power reactors are under construction, the maximum number of nine being in India.

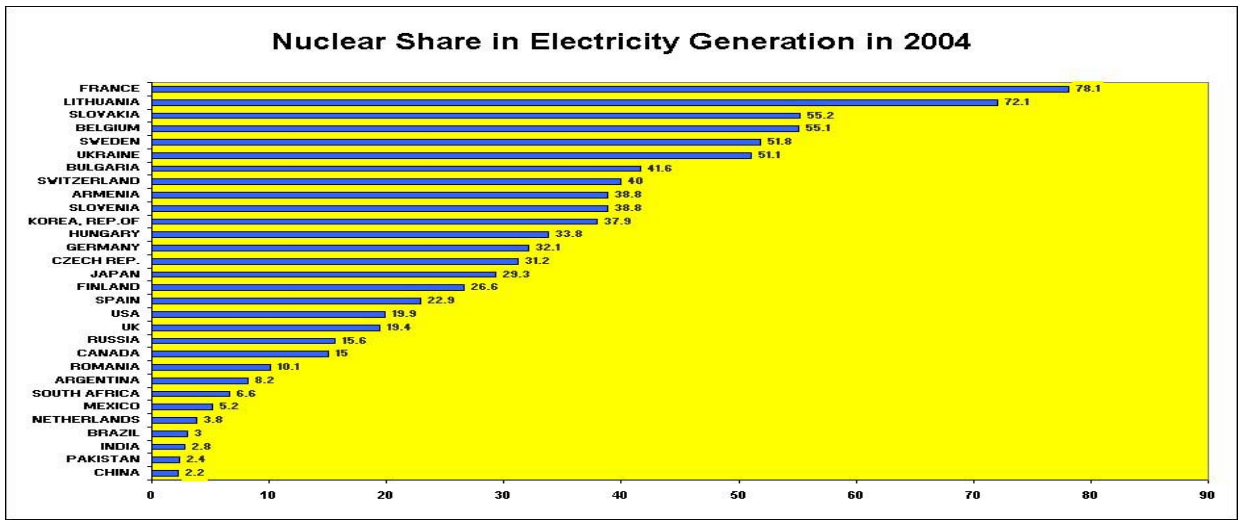
France and Lithuania get more than 70% of their energy requirement from nuclear power, while Slovakia, Belgium, Sweden and Ukraine obtain more than 50%. The USA leads the world in nuclear power production with a total capacity of 99,210 MW(e). The average world availability factor for nuclear reactors is steadily increasing from 1990 and today, it is more than 80%,

The fact that nuclear power reactors perform well even after three decades is borne out from the fact that over 89 operating reactors in the world today are more than 30 years old, and at least 2 reactors churn out electricity even after 40 years of operation.

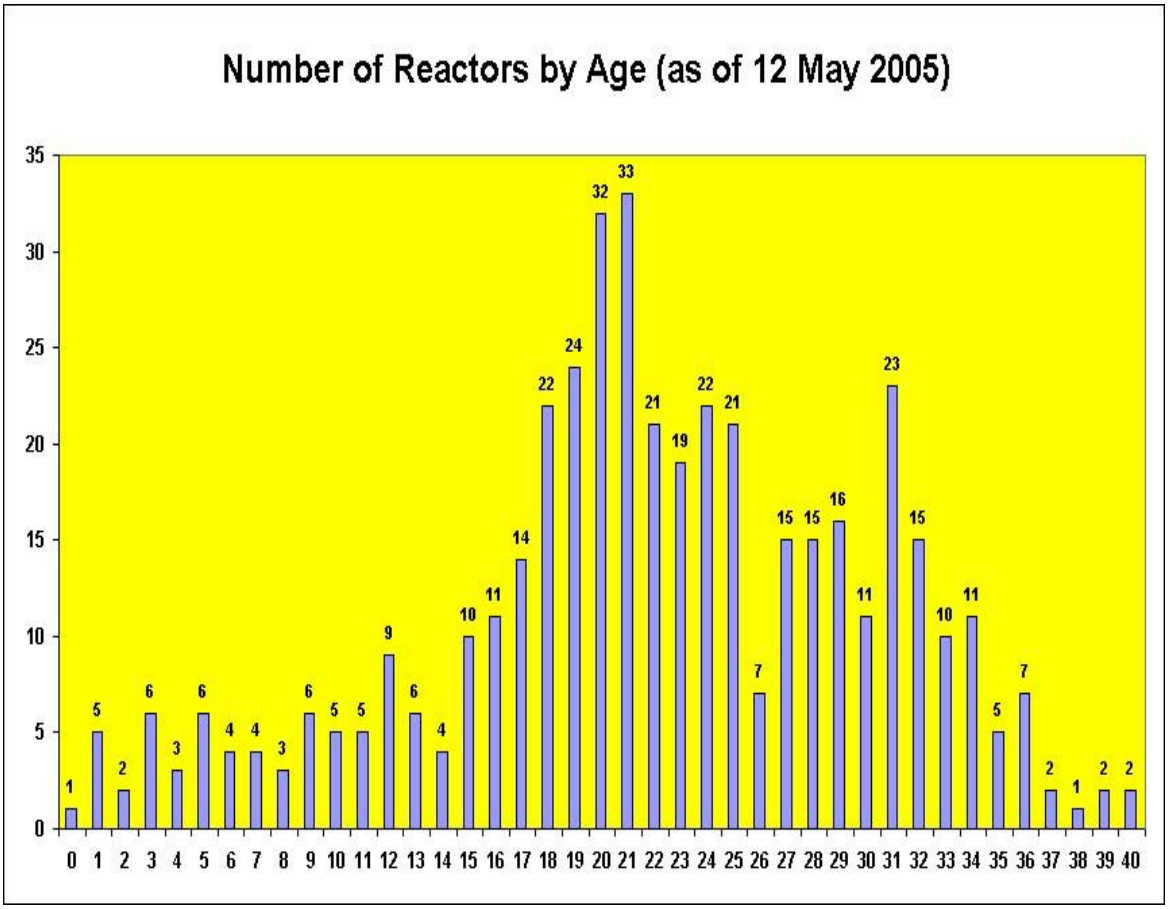
The following graphs and tables present the current scenario in the world nuclear power production.



Source : IAEA, Vienna



Source : IAEA, Vienna



Source : IAEA, Vienna

Nuclear Power Plants Information

Operational & Under construction Reactors by Type

Type	Operational		Under Construction	
	No. of Units	Total MW(e)	No. of Units	Total MW(e)
ABWR	3	3955	3	3904
AGR	14	8380	0	0
BWR	90	78609	1	1067
FBR	3	1039	1	470
GCR	8	2284	0	0
LWGR	16	11404	1	925
PHWR	39	19987	8	3135
PWR	214	205365	1	866
WWER	53	35890	10	9499
Total:	440	366913	25	19866

Source : IAEA, Vienna

Nuclear Power Plants Information

Operational & Under construction Reactors by Country

Country	Reactors in operation May 2005		Reactors under construction May 2005	
	No of Units	Total MW(e)	No of Units	Total MW(e)
Argentina	2	935	1	692
Armenia	1	376	0	0
Belgium	7	5801	0	0
Brazil	2	1901	0	0
Bulgaria	4	2722	0	0
Canada	17	12113	0	0
China	9	6602	2	2500
Czech Republic	6	3548	0	0
Finland	4	2656	0	0
France	59	63363	0	0
			0	0
Germany	17	20339	0	0
Hungary	4	1755		
India	14	2550	9	4092
Iran, Islamic Republic of	0	0	1	915
Japan	54	45468	3	3237
Korea, Republic of	20	16810	0	0
Lithuania, Republic of	1	1185	0	0
Mexico	2	1310	0	0
Netherlands	1	459	0	0
Pakistan	2	425	0	0
Romania	1	655	1	655
Russian Federation	31	21743	4	3775
Slovak Republic	6	2442	0	0
Slovenia	1	676	0	0
South Africa	2	1800	0	0
Spain	9	7585	0	0
Sweden	11	9451	0	0
Switzerland	5	3220	0	0
UK	23	11852	0	0
Ukraine	15	13107	2	1900
USA	104	99210	0	0
Total	440	366,913	25	19,866

The following data from Taiwan, China is included in the totals :

Operational		Under Construction	
No of Units	Total MW(e)	No. of Units	Total MW(e)
6	4884	2	2600

Source : IAEA, Vienna

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