ISSUE NO. 275

DECEMBER 2006

बीएआरसी न्यूज़लैटर

BARC NEWSLETTER

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PHILOSOPHY AND PRINCIPLES OF RADIATION PROTECTION, SECURITY OF RADIOACTIVE SOURCES AND PREPAREDNESS FOR RESPONSE TO RADIOLOGICAL EMERGENCIES

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Radiation and radioisotopes have been widely used in medicine, industries, agriculture and research and their application for the benefit of the society, has significantly increased over the last decade. As a result of this, probability of human beings getting exposed to both external as well as internal radiation, is also on the rise. Accidental exposures of human beings to radiations and the information derived from various experiments have confirmed that radiation can induce a variety of deleterious health effects, if not handled safely or if it is misused. Major evidence implicating radiation effects on human beings, comes from survivors of atomic bomb explosions in Hiroshima and Nagasaki, pioneer X-ray technicians and radiologists, radium dial painters, etc. Most of our present day knowledge on effects of radiation, is based on a careful study and follow-up of these exposed populations. Nuclear accident in Chernobyl, radiological accidents in Goiania, San Salvador etc. and the criticality accident at Tokaimura, Japan, have also provided useful information related to health effects, when human beings are subjected to acute and very high levels of radiation exposure.

There are two types of biological effects due to radiation exposure: stochastic effect and deterministic effect. In stochastic effect, the chance or the probability of the effect occurring, is statistical in nature and is a function of dose without any threshold. Examples are cancer and genetic effects. For deterministic effects, groups of cells or tissues are extensively damaged due to exposure to very high radiation doses and the biological effects may appear, within a few hours to a few weeks, after exposure to ionizing radiation. The effect has a threshold and the severity of the effect, is proportional to the dose received. Reddening of the skin is an example of such effect.

In pursuance of the activities necessary for economic and social progress, one has to ensure the safety of occupational workers, public and protection of the environment. These activities include, the establishment and utilization of nuclear facilities and radiation installations and use of radioactive sources in accordance with the relevant provisions in the Atomic Energy Act, 1962. However, inspite of good design and regulated operations of the facilities, accidents may occur, resulting in radiation emergency situations, which call for comprehensive preparedness programmes, to mitigate their consequences.

Often, particularly in industrial uses of radioactive sources, security of the sources becomes very important. Any unauthorized use of sources or in situations where sources are stolen, or if the sources are not properly handled, there is a potential for acute radiation exposure, which can cause severe health effects. Thus, it is essential that the radiation workers, members of the public and the environment be protected from possible harmful effects of exposure to ionizing radiations. However, it is to be remembered, that the health risks associated with radiation exposure, can only be restricted and not completely eliminated because radiation from outer space (cosmic radiation) and terrestrial radioactive substances, (such as uranium and thorium decay series and ^{40}K) constitute natural radiation background of our environment and are unamenable to control. Natural background radiation level varies from place to place, depending on the radioactivity content of the soil and the altitude of that location. On an average, Indian population is exposed to a natural background radiation dose of 2.4 mSv (240 mRem) in a year.

Modes of radiation exposure

Exposure from an industrial radiography source and exposure of humans to cosmic radiation from space, are examples of external exposure. In work places, workers may be exposed to (i) external exposure from sources that are external to the body and (ii) internal exposure resulting from sources which have gone inside the body due to inhalation of contaminated air or ingestion of contaminated (radioactive) food and water. Exposure from the naturally occurring radioisotope K-40, which is present in the body, inhalation of radon present in environment and exposure from any occupational intake by radiation workers, constitute internal exposure. Internal exposure may also result from a contaminated wound (injection mode).

Philosophy of Radiation protection

Philosophy of radiation protection differs from other systems of protection against conventional agents such as chemical pollutants, which are also potentially harmful to health. The system of radiation protection is comprehensive covering all types of exposures, normal and accidental (potential) and protection of occupational workers, their descendents, individual members of the public and the population as a whole. In addition to this, environmental safety has been given top priority, while controlling radioactive discharges from various nuclear facilities.

The basic principles of radiation protection have been established over the years by an independent, international body of experts called the International Commission on Radiological Protection (ICRP), formed in 1928. In its recent recommendations, the ICRP has emphasized that '*ionizing radiation needs to be treated with care rather than fear* and its risks should be seen in perspective with other risks to which we are all exposed'. The risk of exposure to radiation by occupational workers is acceptable, if the level of risk, is in the range of acceptable risk in other human activities/occupations. Members of the public accept risks, to which the benefits are readily seen by them and where benefits outweigh the risks (e.g., exposure of patients to diagnostic and therapeutic medical exposures). Table 1 shows the reported fatalities in some of the occupations.

Occupation	Fatalities / 100,000 per year
Administrative support, clerical	1
Executive and Managerial	3
Newspaper vendors	6
Police	17
Truck drivers	26
Farm workers	30
Construction labourers	39
Miners	78
Pilots and navigators	97
Sailors	115

Table 1: Comparison of occupational risk (US data)

The three basic principles of radiological protection are:

i. *Justification*: Any procedure involving radiation exposure should be justified. The procedure should result in net positive benefit to the person or group of persons. Decision for a new nuclear power plant can be justified by the government, in view of the electricity requirement due to acute power shortage and environmental pollution considerations of coal-based thermal power plants.

ii. *Optimisation*: Once a procedure involving the use of radiation is justified, the resulting exposure or the dose to the occupational workers and the public should be optimized. A good example can be the necessity of optimization of diagnostic radiation dose, to get maximum diagnostic information about the patient. In industrial radiography applications, action should be taken to prevent radiation exposures to personnel, if it can be achieved without incurring too much financial burden. Generally, cost benefit analysis is carried out to optimize exposures. This is a process for optimizing the use of limited resources for getting maximum benefits, when all risks are considered. The exposures should be maintained As Low As Reasonably Achievable (ALARA).

iii. *Dose limitation*: The upper limits for the justified and optimized exposures, are given by the system of dose limitation. The dose limitation system is evolved by the ICRP, the recommendations of which are accepted by most of the countries. The primary dose limits are based on the stochastic risk estimates, which are mainly based on the data, from the survivors of nuclear bomb explosions, over Hiroshima and Nagasaki.

The current effective dose limit for occupational workers (100 mSv in 5 years, with average annual effective dose of 20 mSv) and for members of the public (1 mSv/year), are based on the stochastic risk coefficient i.e., 5.6 x 10^{-2} / Sv of exposure for occupational workers and 7.3 x 10^{-2} / Sv of exposure for members of the public. In India, the annual limit of dose for occupational workers is 30 mSv, while ICRP recommends the annual maximum of 50 mSv.

Application	Stipulated values	
	Occupational workers	Public
Effective dose	100 mSv in five consecutive years: 20 mSv annual average and 30 mSv in any given year	1 mSv/year
Annual equivalent dose:		
Lens of the eye	150 mSv	15 mSv
The skin	500 mSv	50 mSv
The hands and feet	500 mSv	
Life-time effective dose	1 Sv	
Life saving action	< 500 mSv (This dose can be exceeded if justified; but every effort shall be made, to keep dose below this level and certainly below the thresholds for deterministic effects)	

Note: 1 mSv = 100 mRem

Table 2: Recommended dose limits
Atomic Energy Regulatory Board, India (AERB, 2005)

The compliance to the dose limits (Table 2) should be seen, after adding external dose (recorded by personnel monitoring badge TLD) and internal dose (estimated by bioassay and whole body counting of the exposed personnel). Safety regulations in the BARC facilities including RMC, Parel are enforced by the BARC Safety Council (BSC), which was set-up in the year 2000. The Director, BARC is the Competent Authority for all BSC activities with the Director, Health, Safety and Environment Group, BARC as the Chairman of BSC. Other nuclear facilities, radiation installations and nuclear medicine facilities in the country, are regulated by the Atomic Energy Regulatory Board, formed in 1983. The Chairman, AERB is the Competent Authority to enforce safety related rules, promulgated under the Atomic Energy Act, 1962. Even in BARC facilities, the BSC follows and enforces AERB radiation protection standards.

Under the above said Act, the occupational radiation protection and the waste safety aspects are governed by Radiation Protection Rules – 1971 (revised in 2005) and Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987.

It should be noted that, the dose limits do not apply for medical exposures to the patients where the exposure is only for the benefit of the patient. However, it is recommended that the patient's dose should be optimized. The exposures received by the medical and

Note: 1 mSv = 100 mRem

paramedical staff are considered as occupational exposures and the corresponding dose limits apply for these exposures. Similarly, natural radiation background dose is also not to be included in the dose limits for occupational workers and the members of the public.

Exposure control technique

The basics of the radiation exposure control, particularly from external radiation sources, are the well known variables: Time, Distance and Shielding. This can be described as i) spend minimum time with radiation source / near radiation field, ii) keep sufficient distance from the source of radiation (dose inversely proportional to the square of the distance) and iii) keep or erect some shielding material between the source and the personnel to attenuate radiation. Dense material such as steel or lead can be used to reduce the external dose rate from gamma radiations. Low-density materials such as aluminium or Perspex can be used to reduce beta exposure, energy of the neutrons can be moderated using hydrogenous materials such as paraffin and water and Cadmium / Boron etc. can be used as neutron absorbing material.

Strictly adhering to safe work procedures, use of reliable radiation monitoring instruments/systems and a good safety culture, go a long way, in minimising personnel exposures and improve productivity.

Radiological Safety for Nuclear Reactors

Safety begins right from the site selection stage and then all through the design stage of all nuclear facilities. The sites are selected, preferably away from populated areas with adequate water resource, to meet the cooling requirement of the facilities and the environmental release considerations. The first stage of the safety programme, consists in drawing up a list of all possible situations and planning appropriate protective devices and equipment to cope with them. These situations are classified in four categories, depending on their probability: normal operation; moderate frequency incidents; low frequency accidents and low-probability serious accidents. Each of the categories, has a corresponding radioactivity release limit (due to the limit on the exposure to the public), which should not be exceeded. The facility is then designed, so as to comply to these limits, in design basis accidents. The risks of external forces, such as earthquakes, flooding, aeroplane accidents and malevolent acts are taken into account, when the facility is designed.

Nuclear reactors, while in operation, continuously generate energy from the controlled fission reaction and highly radioactive fission products, in addition to the radioisotopes, produced by neutron activation (including those used in medical and industrial applications). Each reactor will have large inventory i.e., millions of Curie (1 Ci = 3.7×10^{10} disintegrations per second (Bq)) of radioactivity, contained within the reactor. Even during an accidental scenario, large number of barriers are to be penetrated, for the activity to come out of the reactor and reach the public domain. Detailed safety measures at various stages, i.e., site selection, design, construction and operation are incorporated in all nuclear facilities, to ensure that, the radiation exposure to occupational workers as well as to the public, is much below the prescribed limits. The architecture used, consists of a metal enclosure (cladding) which contains the nuclear fuel, a steel vessel which protects the reactor core (extended by the metal envelope formed by the pipes of the primary heat transport system) and the containment building, which surrounds the whole reactor [Fig. 1]. During the operation of the nuclear facilities, it is always ensured, that the releases to the aquatic as well as atmospheric environment, will not lead to any significant exposure to the public. This falls into a small fraction of the annual limit of exposure to the members of the public.

Strict administrative control is also exercised, to ensure safety of the reactor as well as the protection of the public, against any possibility of large scale radioactivity releases. It is always ensured that "The annual risk to the most exposed member of the public due to accidents in a reactor should be extremely small, in comparison to his/her total risk of premature death."

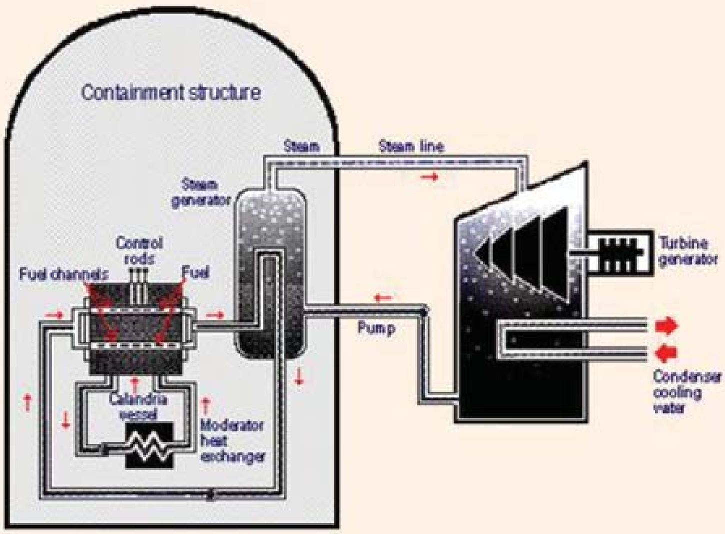

Fig. 1: Simplified diagram of a nuclear power reactor and its containment

The above logic is applicable to all reactors, which should follow three basic principles;

- reduce the probability of any major accident
- reduce the release of radioactivity to the environment
- reduce the radiological consequences even, if release occurs outside the containment.

The radiological impact of any nuclear/radiological emergency, depends on the following parameters:

- Source term of the accident (quantity of radioactivity release)
- Height of the release for the effluents
- Topography (of the area to which it is released)
- Characteristic of the releases
  a) Isotopic composition
  b) Physicochemical form
  c) Delay in release and duration of release
- Meteorological conditions during the release
  a) wind direction b)wind speed c) stability class
- Population distribution with respect to direction and distance from release point
- Level of radioactive deposition / contamination on ground
- Implementation of countermeasures (if carried out in time).

The risk to public from accidents in a nuclear power plant, though the probability is very small, will be predominantly from radiation. The effects of exposure to radiation on life expectancy can be quantified even at low doses, as long as one assumes, a linear no-threshold dose-effect hypothesis. To reflect the two types of health effects of radiation: deterministic and stochastic, the safety goal can be divided into two sub-goals:

1) 'The annual risk of *prompt* death to the most exposed member of the public, due to accidents in a reactor, should be small in comparison to his/her total annual risk of prompt death, due to all accidents', and

2) 'The annual risk of *fatal cancer* to the most exposed member of the public, due to accidents in a reactor,

should be small in comparison to his/her total annual risk of fatal cancer, due to all causes.'

Radiological consequences can be avoided or significantly reduced, if countermeasures can be implemented effectively, which require preparedness for emergency response in place for all nuclear facilities. The fundamental logic for all emergency preparedness is that: money to be spent for response with '*preparedness for emergency response*' would be very small compared to the money required for responding to an emergency, without much '*preparedness for the response*'.

Fig. 2: Zoning around Indian Nuclear Power Plants for emergency preparedness

The zoning concept followed in nuclear power plants (Fig. 2) helps in enforcing the emergency preparedness as well as periodic exercises for such facilities. Systems and methodologies for quick assessment of radiological impact, developed in BARC and kept in readiness, have a very important role, in helping the decision makers, on the appropriate countermeasures at the desired locations.

Chernobyl, Goiania and other nuclear/radiological emergencies have demonstrated that immediately after the completion of the emergency response, there can be immense pressure from the public, public officials and the media, to act to bring the situation to normal. During the response to Chernobyl, many unjustified efforts were carried out because of this pressure, such as improper decontamination and clearance of the affected areas. People were in a hurry to come back to their residences thus forcing the authorities to relax relocation criteria and this resulted in more harm than good. This demonstrates the social, economic and psychological aspects of the preparedness and response to nuclear/ radiological emergencies in public domain.

Application of radioisotopes and security of the sources

To meet the increasing applications of radiation and radioisotopes in medicines, industry, agriculture and research, a large number of isotopes are being currently produced in nuclear reactors and accelerators and are being transported and traded commercially, for these applications, from one corner of the world to the other on a daily basis. Newer engineered safety systems and administrative and regulatory controls are being devised for the safe transport, proper usage and secured storage of these sources. Some of the applications, which use these radioisotopes, are given below:

Procedure	Effective dose	
	mSv	(in mRem)
Chest examination	0.02 – 0.05	2 – 5
Skull	0.1 – 0.2	10 – 20
Abdomen	0.5 – 1.5	50 – 150
Excretory urogram	2.5 – 5.0	250 – 500
Barium enema	3.0 – 7.0	300 – 700
Head CT scan	5.0 – 15.0	500 – 1500
Body CT scan	2.0 – 10.0	200 – 1000

Table 3: Effective dose for various radiological examinations

i. **Medical applications:** Diagnosis (X-ray radiography, Fluoroscopy and Nuclear Medicine procedures) and Therapy (Brachytherapy, telegamma therapy, LINAC teletherapy, Thyroid cancer therapy), etc. The typical radiological examinations and the resultant effective doses are given in Table 3.

ii. Industrial applications: Gamma Irradiator: for food preservation, sterilization of medical products, value addition in gems, etc; Industrial Radiography, Nucleonic gauging, oil well logging, consumer products (smoke detectors) and tracer applications in hydrology.
iii. Research applications: Gamma chamber and discrete sources for laboratory studies.
iv. Agriculture: Nutrition, Rubber Research, Veterinary sciences etc.

Types of radioactive sources

Unsealed sources: The unsealed sources generally are of short half-life and low activity and are used in small quantities as tracers or in medical diagnosis and research applications. These are to be handled safely to avoid contamination and unused or left out sources are to be disposed off safely, as per regulatory guidelines of AERB. The shielding requirements for some typical radionuclides used in nuclear medicine procedures are listed in Table 4, in terms of the Half Value Layer (HVL = thickness to bring the dose rate to one-half of the initial value).

Radionuclide	Major Gamma Energies (keV)	HVL in lead (mm)
I-123	27 (71%), 159 (83%)	0.04
Xe-133	30 (38%), 81 (37%)	0.2
Tl-201	71 (47%), 167 (11%)	0.23
Tc-99m	140 (89%)	0.3
Ga-67	93 (38%), 184 (21%), 300(17%)	0.66
I-131	364 (81%)	3.0
In-111	23 (68%), 171 (91%), 245(94%)	1.3
Rb-82	511 (192%), 777 (13%)	6.0
O-15	511 (200%)	5.5
C-11	511 (200%)	5.5
F-18	511 (194)	5.0
N-13	511 (200%)	5.5

Table 4: Shielding requirements for some typical radionuclides used in nuclear medicine

Sealed Sources: The examples of sealed sources are shown in Table 5 and a number of sealed sources used in different applications in India, is shown in Table 6. Generally, sealed sources are high intensity sources and have industrial and therapeutic nuclear medicine applications. The possession and usage of the sealed sources is regulated by the AERB through various forms of Authorization, Notification, Registration and Licensing. Type approval of equipment using such sources: Regulatory body often approves some equipment after safety evaluation and such equipment go through the 'Type Approval procedures', so that the safety of the operators of such equipment is ensured. Further, provisions exist for surveillance, monitoring, accounting and verification of inventory through inspections and issue of authorization for disposal of sealed "decayed" sources.

The authorised person (licensee) needs to submit periodic reports to AERB, at specified intervals, depending upon the source and the practice for which it is used. The licensee should have a qualified, trained and certified Radiological Safety Officer (RSO) and an approved and well-laid-out 'Emergency Response Plan', to respond to any off-normal events.

A computerised database is maintained at AERB, for all the sources and installations. Periodic reports received from the users, are verified against this database and variations if any, are communicated and rechecked with the licensee. Defaulter on periodic reporting and non-compliance of regulatory requirements can be penalised.

Radioactive waste management

After the source has completed its useful life, it is treated as radioactive waste. Operation of nuclear facilities and processing irradiated fuel, also generate radioactive waste. The main objective of radioactive waste management, is to protect the humans and the environment. The primary classification of radioactive waste is solid, liquid and gaseous. They are further categorized based on the amount and type of radioactivity in the waste. This categorization is necessary for the purpose of safe handling, which includes

Radionuclide	Major gamma-ray photon (MeV)	µGy/h at 1 m from 1 MBq	Half Value Layer in lead (mm)
Ra-226	0.2 – 2.4	0.23	11
Cs-137	0.662	0.09	6
Co-60	1.17; 1.33	0.36	11
Ir-192	0.136 – 1.062	0.13	3
I-131	0.365; 0.640	0.06	3
Na-24	1.37; 2.75	0.50	18
Fe-59	1.10; 1.29	0.17	13
Co-58	0.81; 0.51	0.15	8.5
Zn-65	1.115	0.07	13

Table 5: Sealed sources and the Half-Value Layer (HVL)

Serial No.	Devices	Source	Activity range	Total No.
1	Telegamma	^{60}Co	111 – 444 TBq	263
2	Brachytherapy	^{60}Co, ^{192}Ir, ^{137}Cs	370 MBq – 370 TBq	140
3	Gamma Irradiator	^{60}Co	3.7 – 37 TBq	8
4	Gamma Chambers	^{60}Co	37 - 444 TBq	110
5	Gamma Radiography	^{192}Ir, ^{60}Co	370 – 11.1 TBq	1100
6	Nucleonic Gauges	^{241}Am, ^{241}Am-Be, ^{137}Cs, ^{60}Co	185 MBq – 740 GBq	7500
7	Consumer Products (SD)	^{241}Am	37 kBq	Millions
8	Nuclear medicine, Diagnostic and therapy	^{131}I, ^{125}I, ^{99m}Tc, ^{32}P	few kBq - MBq	125

1Ci = 3.7x 10^{10} Bq = 37 GBq ; 1GBq = 10^{9} Bq = 1000 MBq ; 1 TBq = 10^{12} Bq

Table 6: Sealed sources used in India in medical, industrial and research facilities (source AERB)

appropriate treatment and disposal. The strategies generally adopted in the management of the liquid wastes are: dilute and disperse, delay and decay and concentrate and contain. The agency empowered to do such operations with respect to solid and liquid wastes, is the Waste Management Division of BARC.

Low level liquid effluents are disposed into the sea and high level wastes and alpha-bearing wastes are safely stored and are meant to be disposed off in sites, such as deep geological formations, where the radioactivity will not be able to find its way into water bodies and reach human settlements, either now or in the near distant future. Very low-level gaseous radioactive wastes are released into the atmosphere through the stack, by the respective facility, after ensuring that the radioactive content is reduced to an acceptable level, as stipulatedby the regulatory body, by employing suitable high efficiency filters. The radioactive solid waste should be disposed off in an authorised national disposal facility. The licensee (the facility which generates the waste) applies for authorisation to the regulatory body, for transfer of the spent source (waste) to the disposal facility. Once the source is received at the disposal facility of the Waste Management Division, AERB is intimated and the source inventory record is updated in the database. In case of an imported source, the licensee should return the spent source to the original supplier and take appropriate permissions both from AERB as well as from DGCA (Director General of Civil Aviation) for re-export and air shipment.

Security Controls

AERB is implementing most of the 'reasonably achievable' safety related provisions listed in the IAEA's 'Code of Conduct on the Safety and Security of Radioactive Sources'. The engineered safety/security controls include:

a. locked shielded containers
b. locks and interlocks with radiation monitors for doors, for access control
c. cages, walls and fences for physical protection and the administrative controls followed for the purpose are:
   i. well laid-out procedure for the control of the door key
   ii. access control procedures
   iii. seals on source containers
   iv. appropriate radiation and warning symbols (Fig. 3) on the container
   v. quality assurance measures
   vi. promoting safety and security culture in the users and others (ensured prior to granting licence to possess and use a source, in a practice).

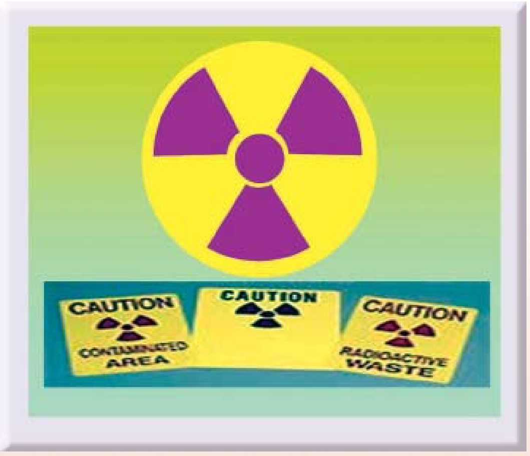

Fig. 3: Radiation symbols

The status of these safety and security provisions is regularly assessed and reviewed during inspections and depends upon changing threat perception, if any.

'Orphan Sources' and the challenges

Adequate security through approval of secured installation and storage of these sources and the regulatory, engineered safety and additional administrative controls, ensure 'cradle-to-grave' control of the sources. A source becomes 'orphan' i.e., goes out of regulatory control due to:

a. lack of or breach of security provisions
b. import of sources without licence, deliberately or out of ignorance
c. loss or misplacement
d. theft
e. unauthorised disposal
f. mishandling of source consignments at entry and exit ports of the country
g. lack of awareness in the public and the officials.

Such sources may also enter into public domain through illegal trafficking. These orphan sources may be malevolently used by unlawful elements in the society which may lead to radiological emergency in public domain. Though the probability is small, accidents during transportation of radioactive sources may also result in

Radiological Emergencies			
Country	Source	Strength in TBq	Health consequences
Istanbul	Co-60	23.5	Severe injury–life threatening
Samut Prakarn	Co-60	15	3 deaths
Tammiku	Cs-137	7.4	1 death
Goiania	Cs-137	50	4 deaths
Lilo	Cs-137	0.164	Severe injury
Lilo	Cs-137	0.126	Severe injury
Yanango	Ir-192	1.37	Severe injury–life threatening
Gilan	Ir-192	0.185	Severe injury
Morocco	Ir-192	1.2	8 deaths
Georgia (RTGs)	Sr-90	1000	Severe injury–life threatening

Table 7: Summary of lost or stolen radioactive source/emergencies

a radiological emergency situation.

Radiological Emergency situations due to orphan sources are reported from many counties (Table 7). The sources responsible were mainly ^{60}Co, ^{137}Cs and ^{192}Ir. The situations resulted in fatalities or severe injuries to people. In India, in medical institutions, there were a few cases of lost brachytherapy sources and those involving industrial radiography sources and nucleonic gauges, though there was no fatality reported in such incidents.

Radiological Dispersal Device (RDD) and Response to Radiological Emergencies

Radiological Dispersal Device (RDD) is defined as 'any device, including any weapon or equipment, other than a nuclear explosive device, specifically designed to disperse radioactive material by disseminating it to cause destruction and damage and additional injury due to the radiation emitted by the material'. It is feared that many radioactive materials, including fission products, spent fuel from nuclear reactors, medical, industrial and research waste may be integrated with conventional explosives, to make a RDD.

Blast and thermal effects following an RDD explosion, would be the only cause for immediate deaths, since lethal levels of radiation exposure from the dispersed materials, requires extremely large quantity of radioactive material, to be integrated with the RDD. Panic caused by fear of radiation, can result into disruption and the required cleanup of the radioactive material and any consequent avoidance of the location (if not cleared of contamination even after many attempts of cleanup) may cause economic losses.

Requirements for Handling Radiological Emergencies:

Taking into account the likelihood of large number of people / area getting contaminated following a radiological accident or RDD explosion, the following are identified as the requirements for an effective response:

- Monitoring large number of people (suspected to be contaminated)
- Radiation Survey of large affected area
- Decontamination facilities (personnel, houses, public places, vehicles, etc.)
- Medical triage and treatment
- Isolation and confinement of contaminated areas
- Removal and disposal of contaminated soil
- Teams ready to work in complex conditions and territories.

Resources required for handling such emergencies are:

- Trained manpower (Emergency Response Teams [ERTs])
- Equipment, radiation monitors and Protective equipment
- Medical facilities
- Transport and Communication facilities for the (ERTs).

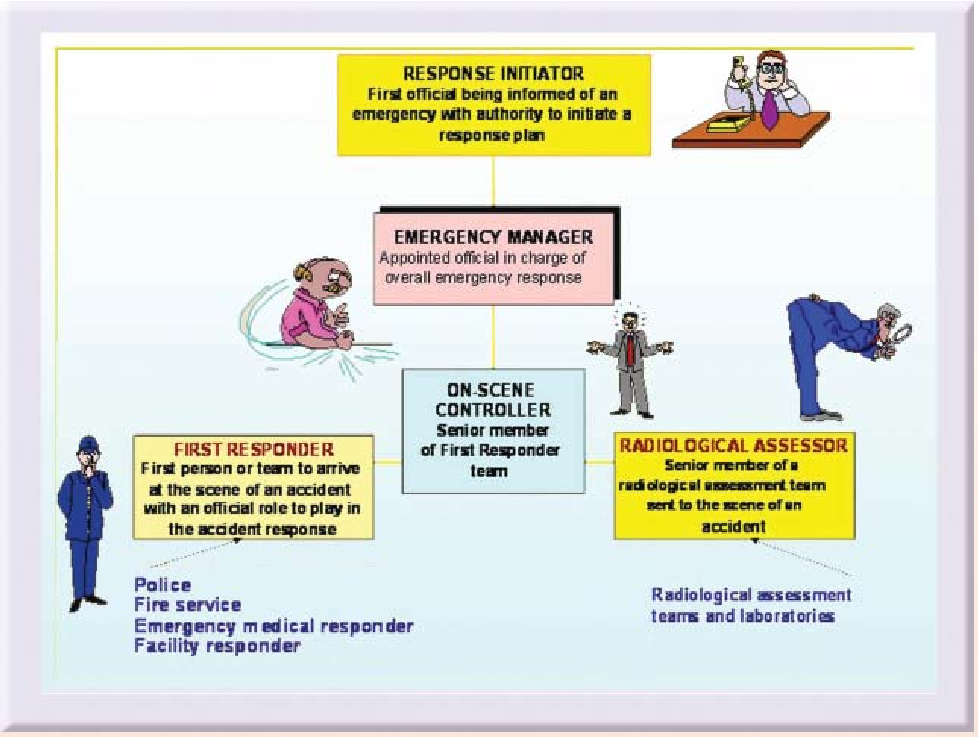

Fig. 4: Organisation to respond to radiological emergencies

Generic response organization (Fig. 4) for such radiological emergencies comprises of:

- First Responder
- Response Initiator (duty officer, emergency service despatcher, facility radiation safety officer)
- Emergency Manager
- On-Scene Controller
- Radiological Assessor.

Following any radiological emergency in public domain, protective actions for inner cordoned area-inside safety perimeter (Table 8) should be carried out. First Responders shall establish and supervise an access and contamination control point as near as possible to the safety perimeter, up wind, inside the security perimeter (Fig. 5), where ambient dose rate is close to background. If for any reason, the radiation level at the contamination control point increases to above 10 μSv/h (1 mR/h), the contamination control point is to be moved to another upwind location within the security perimeter, where the level is close to background or sufficiently low, to allow detection of any source of contamination. Persons

Situation	Initial Distance of Inner Cordoned Area (Safe Distance)
Unshielded or unknown source (damaged or undamaged)	30 m radius or at: - Ambient dose readings of 100 µSv/h - 1.0E+07 Bq/m^2 (gamma/beta deposition) - 1.0E+06 Bq/m^2 (alpha deposition)
Fire, suspected RDD, explosion or fumes, spent fuel plutonium spill	300 m radius (or more to protect against effects of an explosion) or at - Ambient dose readings of 100 µSv/h - 1.0E+07 Bq/m^2 gamma/beta deposition - 1.0E+06 Bq/m^2 alpha deposition

Table 8: Inner cordoned area radius (safe distances) for Radiological Emergencies (suggested by the International Atomic Energy Agency[IAEA])

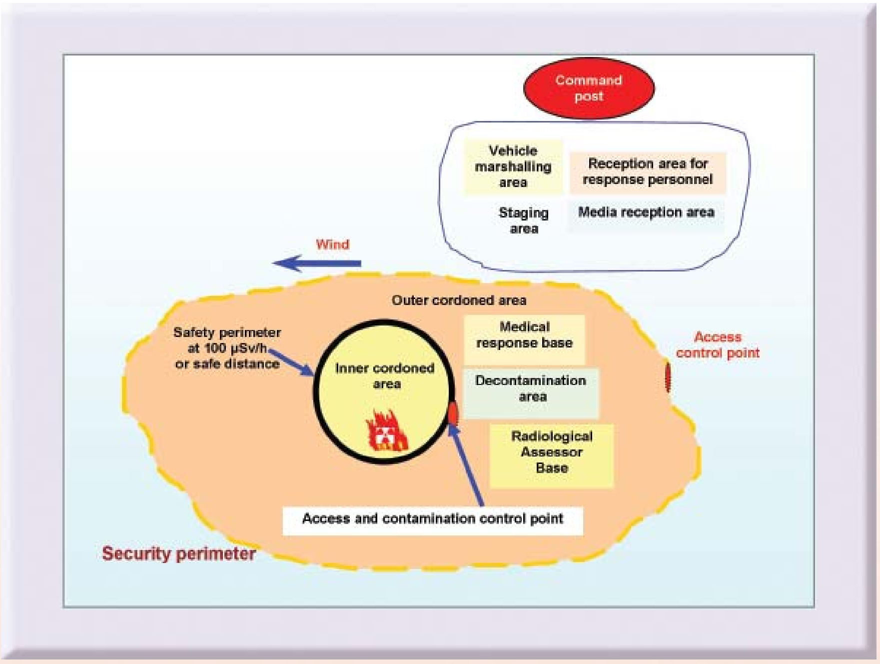

Fig. 5: Typical layout - Safety and security perimeter in case of emergencies leading to radioactive contamination

working in the contaminated area i.e., the first responders have to wear personnel monitoring equipment such as TLD badges and pocket dosimeters (Fig. 6), respirators and other protective clothing (Fig. 7).

Preparedness for response and mitigation of the consequences of radiation emergency, requires the following:

- Appropriate monitoring systems for detecting, locating and identifying sources
- Effective training and awareness programme for all concerned
- A well-coordinated and effective response at national and international level.

A number of sensitive systems and monitoring procedures have been developed for use at installations handling and storing sources, for use in public domain, to detect illegal movement of sources and to locate and identify

Fig. 6: Thermoluminescent Dosimeters (TLDs) and The Digital Pocket Radiation Dosimeter used for dose measurement (external exposure)

Fig. 7: Different types of respirators and protective wear – to be worn by responders working in a contaminated area

and search lost sources. Some of the important systems developed in BARC are:

1. Aerial Gamma Spectrometry System (AGSS) (Fig. 8)
2. Environmental Radiation Monitor with Navigational Aid (ERMNA)[Fig. 8]
3. Compact Aerial Radiation Monitoring System (CARMS) [Fig. 9]
4. Portal Monitor and Limb Monitor (Fig. 10)
5. Vehicle monitor (for inspecting goods/scrap carried by vehicles).

The three systems i.e., AGSS, ERMNA and CARMS (designed for Unmanned Aerial Vehicles[UAV] based aerial surveys) are to be deployed on a mobile platform like aeroplane or helicopter (like in aerial surveys for quick assessment of the radiological impact following release of radioactivity into the atmosphere or large area contamination [Fig. 11]), or in a train, car, van, boat etc. to perform quick environmental monitoring). Many aerial survey exercises [Fig.12) and mobile radiation monitoring surveys are carried out to demonstrate the capability of these systems for a) searching orphan sources and qualitative and quantitative estimation of radioactive contamination over large area on ground. Portal, Limb and Vehicle monitors, are deployed as stationary monitors, to detect unauthorised movement of radioactive material, either by persons or in vehicles in public domain, as well as from nuclear facilities.

Fig. 8: AGSS and ERMNA kept in readiness at the Emergency Response Centre, BARC

Fig. 9: Compact Aerial Radiation Monitoring System (CARMS) for quick assessment of radiological impact using UAVs

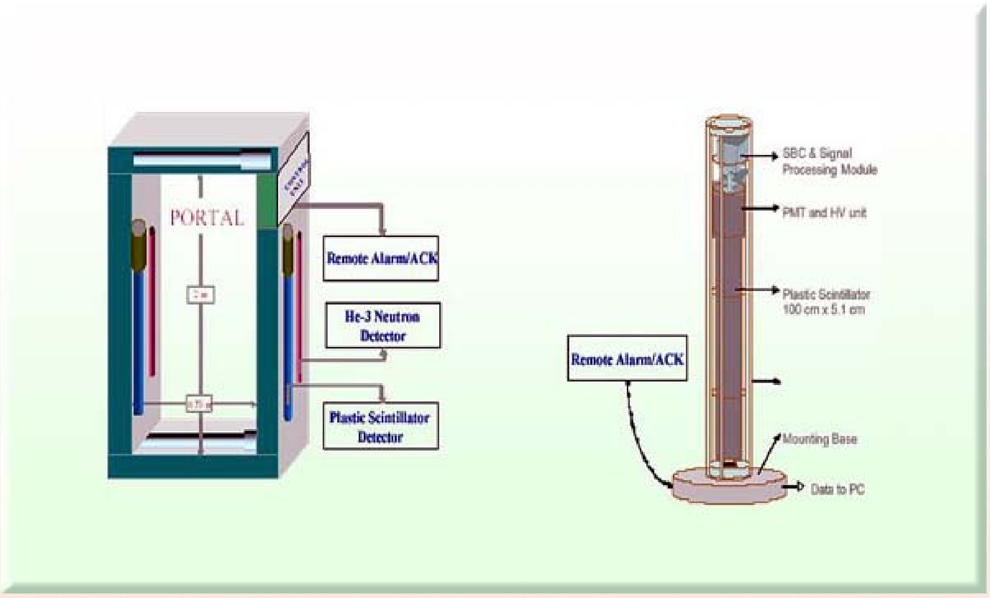

Fig. 10: Portal Monitor and Limb/Pole Monitors developed in BARC for the detection of illegal movement of radioactive materials (Gamma/Neutron)

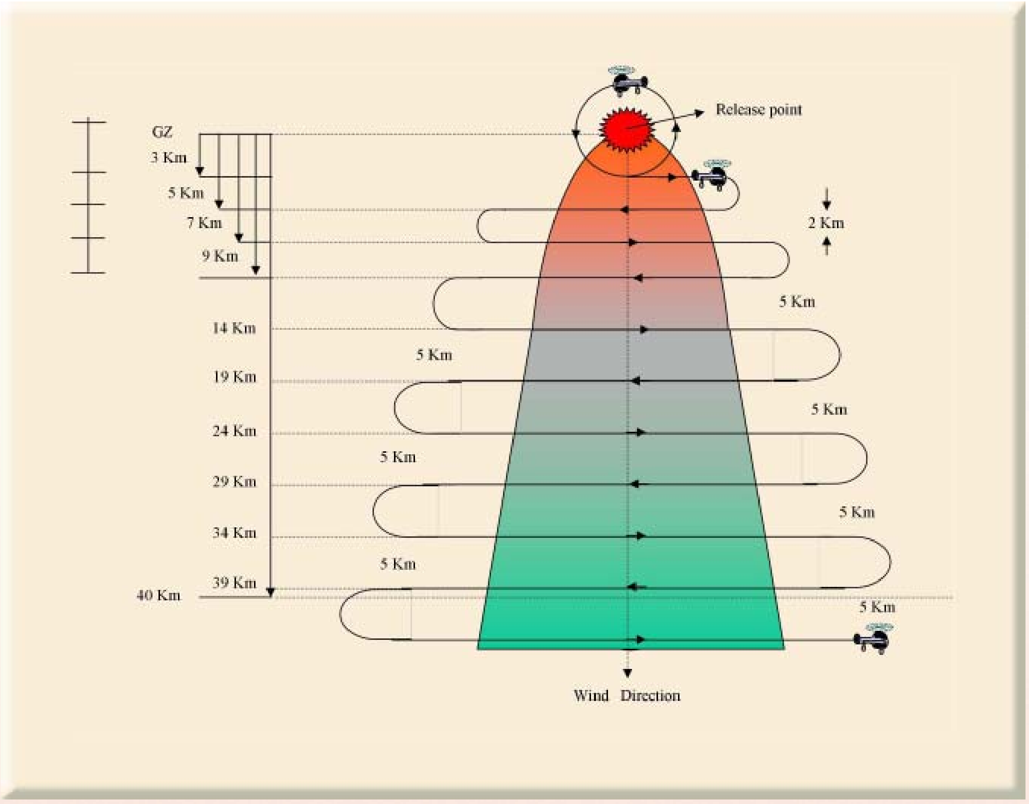

Fig.11: Aerial survey methodology for quick assessment of radiological impact (using AGSS or CARMS) in case of any accidental release of radioactivity to the environment

DAE Emergency Response Centres

A network of eighteen Emergency Response Centres (ERCs) of the Department of Atomic Energy (DAE-ERCs) spread over the country, is being developed with a nodal ERC at BARC for effective response to any nuclear or radiological emergency, anywhere in the country. The ERC closest to the site of the incident, will be activated by the centralised Emergency Communication Room (ECR), Mumbai of the Crisis Management Group (CMG) of the Department of Atomic Energy, on receipt and confirmation of any relevant message. The CMG has been identified as the overall coordinator between various state and central agencies, to facilitate a well-coordinated and effective response to such emergencies. During the last few years, public functionaries like custom officials, police, fire brigade personnel and paramilitary forces are being trained in handling such radiological emergencies, as first responders. Expert Emergency Response Teams (ERTs) are being raised and trained at each DAE-ERC for developing an effective response to such emergencies.

Radiation Safety for new systems and operations

Accelerators

Unlike in 'conventional' radiological safety requirements, the radiological safety in particle accelerators, used for industrial, medical and research purposes, pose unique challenges due to the fact that the sources of radiation

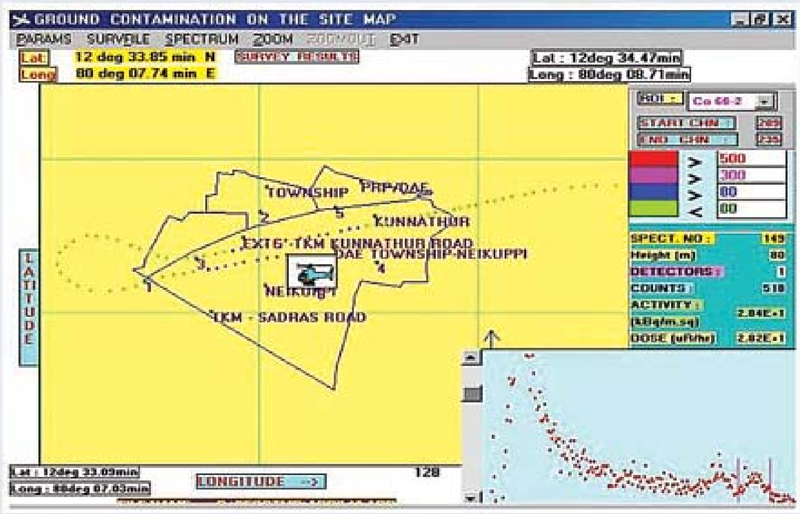

Fig. 12: Display on the PC screen during an aerial survey above simulated contamination using AGSS mounted in a MI - 8 Helicopter

are directional, dynamic, pulsed and mixtures of different types. Though the radiological safety of the occupational workers is ensured by the existing health physics instruments, it is necessary to develop new techniques of measurements and theoretical simulations for dose assessments for exposure to high energy radiations. The biological effects of the high LET radiations and the associated energy distribution are the important considerations which need to be understood and which needs attention. The necessary requirements put new demands on the radiation protection aspects of this fast growing technology.

Thorium Fuel Cycle operations

In the Indian context, expertise is being gained in the reprocessing of thorium rods irradiated in research and power reactors for the utilization of the considerable amount of thorium resources. For India, ^{233}U extraction from the fertile ^{232}Th is the viable option, which has the potential of leading to the 3rd stage of the nuclear power program, i.e. ^{232}Th – ^{233}U based reactors. This option becomes essential considering factors like depletion of limited fossil fuel reserves.

The ^{233}U fuel is associated with the contamination of ^{232}U and also considerably smaller amounts of higher actinides, as compared to U fuel cycle. The highly energetic gamma emitting daughter products generated in the cycle, pose potential radiological hazard in various stages of the fuel cycle operations. There is also a high potential for internal exposure due to inhalation of Thoron and its daughters. The challenging radiological safety aspects of the fuel cycle, are better understood and a lot of experience is gained with respect to work place and personnel monitoring requirements. In view of the higher radiation levels likely to prevail at various stages, state-of-the-art on-line / remote monitoring systems need to be further developed and deployed.

Conclusions

All aspects of safety and security of radiation sources and nuclear facilities, are addressed by the Department of Atomic Energy. The existing regulatory framework ensures effective control on the radiation sources at par with international standards and the average occupational exposures in DAE nuclear facilities, are observed to be less than one tenth of the annual dose limits.

During the design and operation of the nuclear facilities and development of preparedness for response to any accidental situations, safety and protection of the public, from all possible routes of exposure to radiation is taken into account and measures are implemented to ensure minimum risk to the public, even in worst situations. Taking into account the challenges of the illegal trafficking/smuggling of radioactive sources as well as the threat from RDD, state-of-the-art detection systems and monitoring methodologies are developed and kept in readiness for quick impact assessment and to mitigate its consequences during such radiological emergencies.

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STATEMENT OF THE CHAIRMAN, ATOMIC ENERGY COMMISSION, AT THE 50TH GENERAL CONFERENCE OF IAEA, AT VIENNA

Dr Anil Kakodkar, Chairman, Atomic Energy Commission

Following is the statement made by Dr Anil Kakodkar, Chairman, Atomic Energy Commission and Leader of Indian Delegation at the 50th General Conference of the International Atomic Energy Agency (IAEA), on 20th September, 2006, at Vienna.

I would like to begin with a message from our Prime Minister Dr. Manmohan Singh to this fiftieth session of the General Conference of the Agency and I quote:
Quote "I am happy to convey my greetings to members of the International Atomic Energy Agency, its Director-General and members of IAEA Secretariat, on the occasion of this 50th General Conference. Over the past five decades, the Agency has made commendable progress in fulfilling its objectives as laid down in its Statute. The Nobel Peace Prize awarded to Dr. El Baradei and the Agency last year, is a timely and well deserved tribute to the IAEA's contribution.

The International Atomic Energy Agency is an unique organization in the entire UN system, founded on a strong science base and dedicated to spreading understanding of and knowledge about the benefits of atomic energy in a safe and secure manner, with special attention to those areas of the world where developmental needs and aspirations are yet to be fulfilled and are therefore most pressing. With issues related to energy resource sustainability assuming increasing salience and global climate change looming large as arguably the most serious challenge of our time, atomic energy with its immense energy potential and readily available and deployable technologies has become an inevitable and indispensable part of the solution.

Nuclear energy being unique in its ability to regenerate more fuel from uranium and thorium several ten-folds while producing energy, offers us the possibility of meeting global energy requirements in a non-polluting and sustainable manner. However, if we are to be successful in realizing the potential of the atom in meeting our needs, we need to act in concert consistent with the spirit of global harmony and adhering to our respective international commitments. The IAEA and Director-General deserve high compliments for ensuring that the Agency is an effective platform for the global community to work together in its noble mission of 'atoms for peace and prosperity'. India, home to one-sixth of the world population and having embarked on a rapid economic growth path, has a strong interest in utilizing the full potential of atomic energy for national development. I am confident this will be realized, based on our natural endowment of vast thorium resources and the development of effective technologies for their utilization.

We have developed advanced technological capability based on our own self-reliant efforts, while having maintained an unblemished record of responsible behaviour. I am glad that the emerging possibility for expanding civil nuclear cooperation between India and the international community would supplement and complement our domestic efforts to meet the developmental aspirations of our people through additional nuclear energy inputs. We look forward to cooperating with international partners in realizing this possibility.

While nuclear power is of crucial importance for sustainable development, of equal significance are other peaceful applications of atomic energy. The Agency's Programme of Action for Cancer Therapy (PACT) is one such important effort which I am happy to learn is being given special emphasis. India having developed significant experience in affordable cancer – related programmes has been supporting this activity actively and would be pleased to offer a recently developed Cobalt – 60 teletherapy machine (BHABHATRON) as a contribution to the Agency's PACT.

It is my hope that the fiftieth session of the General Conference would be an important milestone in the ongoing and future work of the Agency. I wish you all productive deliberations and progress in your important tasks. My greetings and good wishes to all." Unquote
The Agency and the Department of Atomic Energy, India, have traced history together. This year is also the 50th year of the Bhabha Atomic Research Centre, (BARC), the premier nuclear research centre in India. Dr. Homi Bhabha, the founder of the Indian Atomic Energy Programme, was the President of the first Geneva Conference on 'Peaceful uses of Atomic Energy' held during August 1955.

The activities in atomic energy in India continue to make progress in accordance with the well established three stage nuclear power programme. Units 3 and 4 of the Tarapur Atomic Power Station, which are the 540 MWe indigenously designed and built Pressurised Heavy Water Reactor (PHWR) systems, are now in commercial operation. One more 220 MWe PHWR unit at Kaiga would also become operational before the end of this financial year. The Government of India has recently approved pre-project activities on eight reactor units at four different sites with a total power generation capacity of 6800 MWe. With the completion of these Units alongwith other Units that are already under construction, the total nuclear power generation capacity in India would reach around 14000 MWe.

We now have sixteen reactor units with a total capacity of 3900 MWe in operation. Unit I of Kakrapar Atomic Power Station had a record continuous operation of 372 days before it was shut down for mandatory inspection. The average duration of outage of biennial shutdown has now been reduced to just 26 days.

Major upgrades for ageing management and safety were completed on three PHWR units. The safety upgrades at the two Boiling Water Reactors that started commercial operations in 1969, were completed in just four and a half months. The replacement of all reactor feeders of one of our PHWRs was accomplished for the first time in the world. One of our latest 540 MWe PHWRs was offered for pre-start-up peer review by an expert team of WANO. This was the first ever review of its kind in Asia. We are now ready for implementation of the newly designed 700 MWe PHWR units which would enable further significant reduction in the capital cost per MWe of indigenous PHWR units.

India considers a closed nuclear fuel cycle of crucial importance for implementation of its three stage nuclear power programme with its long-term objective of tapping vast energy available in Indian thorium resources, based on development of effective technologies for their utilisation. This is central to India's vision of energy security and the Government is committed to its full realisation through development and deployment of technologies pertaining to all aspects of a closed nuclear fuel cycle.

As a part of our development efforts in high level radioactive waste management technologies, India achieved two major landmarks this year namely (i) hot commissioning of Advanced Vitrification System (AVS) which employs Joule-heated ceramic melter and (ii) demonstration of Cold Crucible Vitrification Technology. The Fast Breeder Test Reactor (FBTR) at Kalpakkam, which has been the foundation of our fast reactor programme, has shown excellent performance with an availability factor of over 90% in the last few campaigns. The unique U-Pu mixed carbide fuel used in FBTR has reached a record burn-up of 154.3 GWd/t without a single fuel pin failure. This achievement has been possible through a combination of stringent fuel specifications, quality control during fabrication and inputs obtained from the detailed post irradiation examination of fuel at different stages combined with the modeling of the behaviour of the fuel clad and wrapper materials. This year, we have proposed to introduce mixed oxide fuel with 45% Pu in FBTR in order to increase the power level as well as to provide experience on the behaviour of high Pu content oxide fuel in fast reactors. Last year I had informed that the carbide fuel discharged from FBTR at a burn-up of up to 100 GWd/t had been successfully reprocessed. This experience in the reprocessing campaigns have provided significant inputs to the design of the equipment and flow sheet for the Demonstration Fast Reactor Fuel Reprocessing Plant [DFRP], which is in an advanced stage of construction.

The construction of 500 MWe Prototype Fast Breeder Reactor (PFBR) is on schedule and is expected to be commissioned by the year 2010. In keeping with our philosophy of efficient utilization of a fuel material by closing the fuel cycle, we have embarked on the design and construction of a fuel cycle facility to cater to the PFBR.The facility will be commissioned by 2012.

Simultaneous with the construction of the PFBR we have already initiated programmes towards the conceptualization of the FBRs to follow, with the objective of further enhancing the fuel performance as well as making the energy production more economical. To ensure rapid growth in the fast reactor programme for meeting the energy needs in the country, we have already embarked on R&D programmes targeting towards the introduction of metallic fuel in fast reactors, which would provide much higher breeding. A host of R&D programmes in associated areas such as advanced materials, structural mechanics, heat transport, in-service inspection systems, physics, chemistry, safety, etc., are being pursued to provide R&D inputs for further advancement of FBR technology. This comprehensive and indigenous programme in all major areas provides a strong foundation for India's fast reactor programme. India is also prepared to contribute to international efforts in scaling new technological frontiers in this field as an equal partner with other countries having advanced technological capabilities.

Thorium utilization is the long-term core objective of the Indian nuclear programme for providing energy independence on a sustainable basis. The third stage of the programme is thus based onThorium-Uranium-233 cycle. We are actively engaged in developing 300 MWe Advanced Heavy Water Reactor (AHWR). The design of this reactor incorporates several advanced features to meet the objectives being set out for future advanced nuclear reactor systems. A critical facility to validate physics design of AHWR will be functional this year. The facility is flexible enough to study the physics of advanced systems, including source driven systems, in future. Development of high current proton accelerator and spallation source for Accelerator Driven Sub-Critical Systems (ADS) is also being pursued. Such systems would offer the promise of shorter doubling time, even with Thorium and incineration of long lived actinides and fission products, thus leading to the possibility of eliminating long-lived radioactive waste. A Compact High Temperature Reactor (CHTR), with 100 kW thermal power rating, is being developed as a demonstrator of technologies relevant for next generation high temperature reactor systems. Such reactor systems will address the needs such as electricity generation in remote places, production of alternative transportation fuel such as hydrogen and refinement of low–grade coal and oil deposits to recover fossil fluid fuel.

India has had a fusion research programme of its own since the early eighties. Two tokamaks have been indigenously built. The Steady State Super conducting Tokamak-SST-1 is currently undergoing commissioning tests. India has recently joined ITER as one of seven full partners. On the basis of indigenous experience and expertise available in Indian industry, India will contribute equipment to ITER and will participate in its subsequent operation and experiments. Indian scientists are also working on establishing an India- based Neutrino observatory for doing comprehensive research in Neutrino Physics, an area in which Indian research groups have sustained interest and have made significant contributions. We would welcome participation of interested international scientific groups in this effort. The 2.5 GeV synchrotron radiation source Indus-2 being set up at Raja Ramanna Centre for Advanced Technology, Indore, has started functioning. The utilization of the storage ring for condensed matter studies using the synchrotron radiation from the bending magnet beam lines has also begun.

The excellent safety record of Indian reactors and other facilities has been achieved through sustained Research and Development programmes. As part of the safety studies on nuclear containment structures, the construction of a 1:4 size containment test model has been initiated at Tarapur. The ultimate load capacity of the containment would be studied on this test model and the experimental results would be available to the participants of a round robin exercise, which is being organized by us. We would welcome participation of interested research groups in this exercise.

As in the previous years, we have been interacting with the IAEA very closely in almost all its activities. We have been an active participant in the IAEA – INPRO programme. We were one of the six countries to perform a national case study for development of INPRO methodology under INPRO phase-1B part-1 activity which was done using the Indian Advanced Heavy Water Reactor. We are also involved in joint case studies on fast reactor with closed fuel cycle and high temperature reactors for hydrogen generation. We have also contributed to chapters of the INPRO document on guidance and methodology for assessment of economics, safety and waste management. We strongly support international cooperation through cooperative research and joint initiatives, as envisaged under INPRO phase-2. India remains supportive of the IAEA fulfilling its statute responsibilities, particularly the developmental and international co-operative dimensions of nuclear energy.

The Indian programme on the application of radioisotope and radiation in health, agriculture, industry, hydrology, water management and environment for societal benefit has a close match with several activities of the Agency. Our experts thus take active part in all Agency activities. As a founder member, we participate actively in RCA activities. Last year, we had hosted 6 events in India. We have also hosted 34 IAEA Fellows and Scientific visitors. I am glad to inform this gathering that the International Union Against Cancer (UICC) selected the Tata Memorial Centre in Mumbai for the "Outstanding UICC Member organization" award for its outreach programmes related to cancer control. PACT programme drawn up by the Secretariat deserves our fullest and speedy support.

A special event on "New Framework for Utilisation of Nuclear Energy in the 21st Century: Assurances of Supply and Non-Proliferation" is currently in progress as part of this General Conference. Out of the current fleet of 443 nuclear power reactors operating in the world, less than half are under IAEA safeguards. Even in this scenario and with a very slow growth of nuclear power in the last two decades, the volume of human and financial resources needed for implementation of IAEA safeguards have constituted a large fraction of the resources available to the Agency. Now with anticipated rapid growth in demand for nuclear power, mainly in the developing countries, cost effective safeguards are essential so that the safeguard system does not itself become an hindrance to the development of nuclear power while at the same time providing the necessary assurances in terms of verification. India therefore feels it is necessary to look for institutional as well as technological solutions with enhanced proliferation resistance along with an assured fuel supply, without adversely affecting long-term sustainability of nuclear fuel resources. Thorium offers a very important and attractive solution from this perspective and we urge the Agency and its members to give serious consideration of the possibilities offered by the Thorium route.

Over the years India has developed advanced capabilities in the utilization of thorium, as a part of its strategy to enhance nuclear capacity through a closed nuclear fuel cycle that would enable timely deployment of its thorium reserves. We are convinced that this is a viable and sustainable strategy for India's and global long term energy security. Seen in the context of nuclear power becoming a significant fraction of energy supply in a world where everyone is assured of a minimum of 5000 KWh of energy in a year, entire global Uranium if used in once through mode would last only a few tens of years. Even with a shorter term perspective of deployment of a proliferation resistant nuclear energy system that could address the need for incineration of available surplus plutonium, the use of thorium, in reactors using proven technologies, presents a vastly superior option as compared to other options based on fast reactors. In my presentation at the special event tomorrow I would elaborate on this aspect further. I will urge the IAEA to give a further boost to its activities that could lead to an early expansion of global reach and volume of deployment of nuclear energy, using thorium based fuel cycle as one of the important routes to reach the goal.

We have been constantly reminding the Agency of the need to maintain a balance between its promotional and safeguards related activities. The risk arising out of global climate change and rapid depletion of global fossil fuels is real and substantial. We believe that future enhancement of the share of nuclear energy as a clean energy source is possible and feasible in a manner that satisfies the imperatives of nuclear safety and security. Let us therefore resolve that we would pool our scientific and technological abilities together in finding holistic solutions so that the next 50 years are seen as the golden period of nuclear energy development in meeting global energy needs. As a responsible state with advanced nuclear technological capabilities, India is prepared to play its part in this glorious endeavor.

EXPERIMENTAL STATION OF EXAFS SYNCHROTRON BEAM LINE

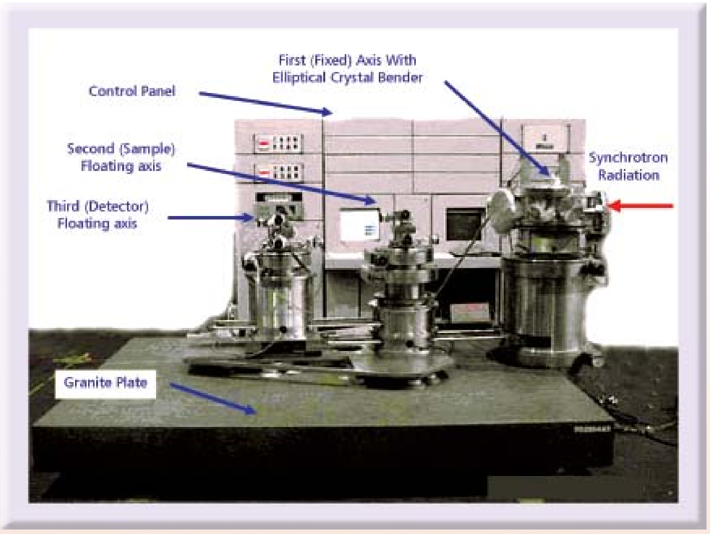
Centre for Design & Manufacture (CDM) has designed and developed 19-axes, PC - operated, experimental station of Extended X-ray Absorption Fine Structure (EXAFS) Synchrotron beam line as per the optical and physics parameters specified by the Spectroscopy Division of BARC. This PC - operated experimental station, will be used for conducting various types of experiments (like measurements of fine structure, interatomic distances, degree of disorder, radial distribution etc), using the high energy X-ray beam, taken from the Synchrotron beam.

Complete experimental station, consists of 19-axes high precision motorized instruments/stages, all manufactured at CDM, mounted on three vertical axes. First axis is fixed axis and consists of a vacuum chamber containing a 460 mm long Si single crystal, bent in elliptical shape with the help of a crystal bender. This chamber is mounted on X-Y-Z and Rotary table for alignment of the bent crystal with respect to the synchrotron beam. Cooling arrangement for Si crystal inside the vacuum chamber has also been provided. Purpose of this bent crystal, is to focus the X-ray beam of the selectable energy from 5Kev to 20Kev, on the sample axis. First axis also consists of radial drive and rotational drive arrangement, for the Second and Third axes.

Second and Third axes are known as floating axes, because they rest on granite plate, with air cushion pads. Whenever radial (range 834mm max) or rotational (range -10° to 38°) movement of Second or Third axis or both the axes is required, the air cushion pads are actuated by supplying the air at the required pressure, and both the axes i.e. Second and Third axes start floating just above the granite plate, keeping a gap of approx. 30 micron between the top surface of granite plate and the bottom surface of air cushion pads. In this condition only, the motors for radial or rotary drive of floating axes are actuated, to get the required movement and position of Second and Third axes with radial position accuracy of 0.010mm and rotational accuracy of 15 arc second.

Both Second and Third axes consist of motorised X, Y, Z, Rotary and Tilt stages, for precise positioning of the Sample piece and the Detector. All the motors are PC - controlled and are provided with encoders for feedback and accurate positioning of the movements.

The complete system was first assembled and tested at CDM by the Spectroscopy Division and the same was despatched and installed at INDUS-II, RRCAT, Indore.



Experimental Station of EXAFS Beamline

NATIONAL SAFETY DAY CELEBRATION AT BARC

The National Safety Day was celebrated on 3rd March, 2006 at the Centre with a day-long programme. An exhibition was arranged at the Central Complex Auditorium, BARC, Trombay. Display of safety posters on different themes as well as safety related information charts, conducting safety slogan and safety poster competitions and screening of safety films were the highlights of the programme.

H.S. Kushwaha, Director, Health, Safety and Environment Group, BARC and Chairman BARC Safety Council inaugurating the Safety Exhibition

The safety exhibition was inaugurated by Shri H.S. Kushwaha, Director, Health, Safety and Environment Group, BARC and Chairman, BARC Safety Council. In appreciation of the exhibition, he lauded the efforts taken towards inculcating safety awareness among the employees. Controller, BARC and many Heads of Divisions graced the occasion. A number of employees of the Centre at all levels, took active part in the programme.

Posters displayed at the exhibition

As part of efforts in promoting safety through the educational and motivational activities under the Accident Prevention Programme, Industrial Hygiene and Safety Section (IHSS), Radiation Safety Systems Division, organises this one-day common safety programme annually. The result of the Safety Poster Contest-2006 (organised at the Centre) were displayed at the exhibition. To evaluate the Best Safety Posters, Head, Radiation Safety Systems Division constituted a committee consisting of Dr Pushparaja, Head, RHC Section, Dr U.V. Phadnis and Dr R.M. Bhat, RS Section, RSSD and Dr R.M. Tripathi, Environment Assessment Division. Members of Industrial Hygiene and Safety Section coordinated with the committee.

BARC SIGNS MOU WITH ONGC FOR R&D ON THERMOCHEMICAL PROCESSES FOR HYDROGEN PRODUCTION FROM WATER

The Bhabha Atomic Research Centre and the Oil and Natural Gas Corporation Limited, New Delhi signed a Memorandum of Understanding (MoU) to undertake collaborative R&D work on the Thermochemical Processes, for Production of Hydrogen from water. This R&D effort is to harness nuclear energy for producing Hydrogen, a clean secondary fuel, from water and is in line with the DAE and Government of India's long term perspective of development of environment friendly systems, for sustainable growth and energy security.

The R&D plans and projects of BARC and ONGC complement and supplement each other and include experimental and theoretical investigations of alternative processes or steps. The MoU will remain in force for a period of five years and its validity can be extended by mutual agreement based on progress of the work.

This wide ranging and technologically challenging R&D is expected to generate crucial process information/data and help demonstrate the feasibility, stability and efficiency of thermochemical processes for production of Hydrogen from water.

Mr D.S. Shukla, Director, Chem. Engg. & Tech. Group and Dr D.M. Kale, Executive Director (R&D) Head, ONGC Energy Centre, ONGC Ltd., exchanging signed MoU. Also present (right to left) are Mr A.K. Singhal, Head, Chemical Technology Division, Mr I.V. Dulera, RED, Mr R.P. Agarwal, TT&CD, Mr C.S.R. Prasad, CTD., Mr M.P. Sreekumar, CTD, Ms N.J. Thomas, ONGC, Dr B.N. Prabhu, ONGC, Mr Chatar Singh, E.D. Chief IOGPT/IEOT, ONGC; Mr Ashish Jain, ONGC, Mr A.K. Sonawane, GM, Head IEOT, ONGC.

PRIMARY SLIT ASSEMBLIES FOR SYNCHROTRON INDUS - II BEAMLINE

The Centre for Design & Manufacture (CDM) has designed and manufactured six PC- operated UHV - compatible water-cooled primary slit assemblies for synchrotron beam lines. These six primary slit assemblies, are for EDXD, PES and SAXS/WAXS beamlines. Purpose of the slit is to define the shape and size of the synchrotron beam and also to absorb the heat energy from the outer periphery of the beam.Slit opening is controlled by four independent jaws (two vertical and two horizontal) as shown in Fig. 1. Maximum opening size of the slit is 60 x 30 mm and minimum is 0 x 0 mm (completely closed). Range of movement of single vertical jaw is from –2 mm to 15 mm and of single horizontal jaw is –2 mm to 30 mm, with a resolution and repeatability of position as 1 micron.

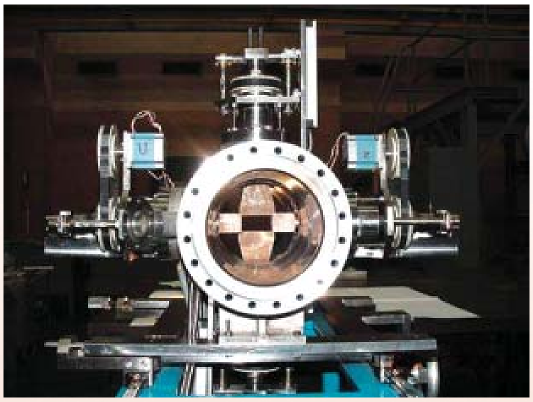


Fig. 1: Four slit jaws showing maximum opening size of 60x30mm

Each slit jaw assembly (Fig. 2) consists of tungsten carbide slit edge fixed on a water-cooled copper block for heat removal. Cooling tubes and stepper motor drive mechanism (for linear travel of each slit) are housed inside the SS membrane bellows for isolating them from the vacuum. Alignment arrangement has also been provided to align each jaw independently with respect to each other and also with respect to chamber axis. Complete slit assembly is mounted on a vibration-isolated stand, having manual X-Y & Z adjustment (Fig. 3).

Fig. 2: Slit jaw assembly

Fig. 3: Primary slit assembly

slit opening (movement of each slit jaw) is controlled through a PC- based control console. Proximity switches and Linear encoders are also provided for ensuring home position of slit edges and to know the actual position of slit edges respectively.

GOLDEN JUBILEE CELEBRATIONS OF BARC BEING ORGANISED BY THE BARC FACILITIES AT KALPAKKAM

Golden Jubilee of BARC which is being celebrated at BARC, Mumbai is also being celebrated at BARC Facilities, Kalpakkam. The celebration programmes, spanning over a period of one year, will consist of open houses, educational and quiz programmes for school children, providing facilities for upgradation of laboratory infrastructure in schools (both rural and urban), exhibitions, popular talks by eminent personalities and finally, a seminar highlighting the activities of BARC Facilities. The Golden Jubilee celebration at Kalpakkam was inaugurated on 12 June, 2006 by noted agricultural scientist Padma Vibhushan Prof. M.S. Swaminathan. The meeting was presided over by Dr S. Banerjee, Director, BARC. Earlier, Mr S. Basu, Facility Director, BARC Facilities, welcomed the gathering. Mr S. D. Misra, Director, Nuclear Reprocessing Group, BARC released a colour brochure highlighting the activities of the BARC Facilities at Kalpakkam. Dr Swaminathan received the first copy. Mr M.P. Patil, the first Facility Director of BARC Facilities and under whose leadership KARP was commissioned, was felicitated at the function. Dr S.V. Narasimhan, Head, Water and Steam Chemistry Division and Convenor of the Golden Jubilee Celebrations, proposed a vote of thanks.

After the function, Professor Swaminathan and Dr Banerjee interacted with the press. A site visit was also arranged and the press was taken to the Waste Immobilisation Plant (WIP) project and Nuclear Desalination Demonstration Plant (NDDP) project. Later on, Prof. Swaminathan, accompanied by Prof. P.C. Kesavan, Homi Bhabha Chair and Distinguished Fellow, MSSRF, Chennai, visited the Water and Steam Chemistry Division and appreciated the biology-related work being carried out.

Padma Vibhushan Prof. M.S. Swaminathan, Mr S. Basu, Facility Director, BARC Facilities, Dr S. Banerjee, Director, BARC. Mr S.D. Misra, Director, Nuclear Reprocessing Group, BARC, Mr M.P. Patil, the first Facility Director of BARC Facilities, Dr S.V. Narasimhan, Head, Water and Steam Chemistry Division and Convenor of the Golden Jubilee Celebrations

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


Ms Babita Tiwari


Dr M. Pande


Mr Anupam Dixit


Dr S.K. Deb


Dr G.P. Kothiyal

श्रीमती बबीता तिवारी, तकनीकी भौतिकी एवं प्रोटोटाइप इंजीनियरी प्रभाग (टीपी एंड पीईडी), ने सितंबर 15-16, 2006 के दौरान बहुप्रयोजन हॉल, भापअ. केंद्र के प्रशिक्षण केंद्र के अतिथि ग्रह, अणुशक्ति नगर, मुंबई में ग्लास/ ग्लास-सिरामिक्स (NSGC - 06) के विज्ञान एवं तकनीक की राष्ट्रीय परिचर्चा में प्रिपिरेशन एन्ड करेक्टरैज़ेशन आफ फासफेट ग्लासिस कन्टेनिन्ग टिटेनियम नामक शोधपत्र की प्रस्तुति पर सर्वश्रेष्ठ पोस्टर पुरस्कार प्राप्त किया। इस शोधपत्र के सह लेखक डॉ एम पांडे, एचपीपीडी, भापअ केंद्र; श्री अनुपम दीक्षित, टीपी एंड पीईडी, भापअ केंद्र; डॉ एस के देब, एचपीपीडी, भापअ केंद्र और डॉ जी पी कटियाल, टीपी एंड पीईडी, भापअ केंद्र भी थे।

Ms Babita Tiwari of Technical Physics & Prototype Engineering Division (TP&PED), has received the Best Poster Paper Award for the paper entitled "Preparation and characterization of phosphate glasses containing titanium" presented in the National Symposium on the Science and Technology of Glass/Glass-Ceramics (NSGC-06), during September 15-16, 2006, held in Multipurpose Hall, BARC Training School Guest House, Anushakti Nagar, Mumbai. Co-authors of the papers were: Dr M. Pande, HPPD, BARC; Mr Anupam Dixit, TP&PED, BARC; Dr S.K. Deb, HPPD, BARC and Dr G.P. Kothiyal, TP&PED, BARC


Dr R.N. Pandey

डॉ राज नारायण पांडेय, नाभिकीय कृषि एवं जैव तकनीकी प्रभाग को वर्ष 2005-06 के राज भाषा भूषण पुरस्कार से सम्मानित किया गया। यह पुरस्कार राजभाषा हिंदी के प्रचाार-प्रसार में उनके उत्कृष्ट योगदान हेतु प्रदान किया गया। यह पुरस्कार दिनांक 26-10-2006 को नवम् अखिल भारतीय राजभाषा सम्मेलन के उद्घाटन सत्र में परमाणु ऊर्जा विभाग के सचिव डॉ अनिल काकोडकर के द्वारा प्रदान किया गया। डॉ पांडेय भाभा परमाणु अनुसंधान केंद्र के नाभिकीय कृषि एवं जैव तकनीकी प्रभाग से जुलाई 31, 2006 को सेवानिवृत्त हुए।

Dr Raj Narayan Pandey, Nuclear Agriculture & Bio Technology Division has been honoured with Raj Bhasha Bhushan Award for the year 2005-06. This award was granted to him in recognition of his outstanding contribution in propagating Raj Bhasha Hindi. This award was bestowed on him by Dr Anil Kakodkar, Chairman, Atomic Energy Commission in the inauguration ceremony of the 9th Akhil Bharatiya Raj Bhasha Conference on 26-10- 2006. Dr Pandey retired on July 31, 2006 from Nuclear Agriculture & Bio Technology Division Bhabha Atomic Research Centre.

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Editorial Management : Ms. S.C. Deokattey, Computer Graphics & Layout : N. Kanagraj, SIRD, BARC

BARC Newsletter is also available at URL: http://www.barc.gov.in (For private circulation only)