GOVERNMENT OF INDIA

ATOMIC ENERGY REGULATORY BOARD

ANNUAL REPORT 2010-2011

ATOMIC ENERGY REGULATORY BOARD

The Atomic Energy Regulatory Board (AERB) was constituted on November 15, 1983 by the President of India by exercising the powers conferred by Section 27 of the Atomic Energy Act, 1962 (33 of 1962) to carry out certain regulatory and safety functions under the Act. The regulatory authority of AERB is derived from the rules and notifications promulgated under the Atomic Energy Act, 1962 and the Environment Protection Act, 1986. The mission of the Board is to ensure that the use of ionizing radiation in India does not cause undue risk to health of people and the environment. Currently, the Board consists of Chairman, Vice-Chairman, three Members and a Secretary.

AERB carries out its functions through highly qualified work force and specialist committees under the guidance of the Board. Apex level committees include Safety Review Committee for Operating Plants (SARCOP), the Safety Review Committee for Applications of Radiation (SARCAR), Advisory Committees for Project Safety Review (ACPSRs), Advisory Committee on Radiological Safety (ACRS), Advisory Committee on Industrial and Fire Safety (ACIFS), Advisory Committee on Occupational Health (ACOH) and Advisory Committee on Nuclear Safety (ACNS). The ACPSRs recommend to AERB issuance of authorizations at different stages of projects of the Department of Atomic Energy (DAE), after reviewing the submissions made by the project authorities based on the recommendations of the associated Project Design Safety Committees.

SARCOP carries out safety surveillance and enforces safety stipulations in the operating units of the DAE. SARCAR recommends measures to enforce radiation safety in medical, industrial and research institutions, which use radiation and radioactive sources. AERB receives advice on development of safety codes and guides and on generic nuclear safety issues from ACNS. ACRS, ACIFS and ACOH advise AERB on safety matters relevant to their fields of specialization. The administrative and regulatory mechanisms in place ensure multi-tier review of all safety matters by experts in the relevant fields available nationwide. These experts come from reputed academic institutions, R&D organizations, industries and Governmental Agencies.

AERB has a Safety Research Institute (SRI) at Kalpakkam, which carries out research in various safety-related topics and organizes seminars, workshops and discussion meetings periodically.

AERB has seven technical divisions. Chairman, Vice-Chairman and Directors/Heads of Divisions and Head, SRI constitute the Executive Committee, which meets periodically and takes decisions on important matters related to the functioning of the organization. AERB enforces the following Rules issued under the Atomic Energy Act, 1962:

- Atomic Energy (Radiation Protection) Rules, 2004.
- Atomic Energy (Working of the Mines, Minerals and Handling of Prescribed Substance) Rules, 1984.
- Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987.
- Atomic Energy (Factories) Rules, 1996.
- Atomic Energy (Control of Irradiation of Food) Rules, 1996.

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ATOMIC ENERGY REGULATORY BOARD
NIYAMAK BHAVAN, ANUSHAKTI NAGAR
MUMBAI-400 094

Website : www.aerb.gov.in

THE FUNCTIONS OF THE ATOMIC ENERGY REGULATORY BOARD

- Develop safety policies in both radiation and industrial safety areas.
- Develop Safety Codes, Guides and Standards for siting, design, construction, commissioning, operation and decommissioning of different types of nuclear and radiation facilities.
- Grant consents for siting, construction, commissioning, operation and decommissioning, after an appropriate safety review and assessment, for establishment of nuclear and radiation facilities.
- Ensure compliance with the regulatory requirements prescribed by AERB during all stages of consenting through a system of review and assessment, regulatory inspection and enforcement.
- Prescribe the acceptance limits of radiation exposure to occupational workers and members of the public and acceptable limits of environmental releases of radioactive substances.
- Review the emergency preparedness plans for nuclear and radiation facilities and during transport of large radioactive sources, irradiated fuel and fissile material.
- Review the training program, qualifications and licensing policies for personnel of nuclear and radiation facilities and prescribe the syllabi for training of personnel in safety aspects at all levels.
- Take such steps as necessary to keep the public informed on major issues of radiological safety significance.
- Promote research and development efforts in the areas of safety.
- Maintain liaison with statutory bodies in the country as well as abroad regarding safety matters.
- Review the nuclear safety aspects in Nuclear Facilities under its purview.

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GENERAL

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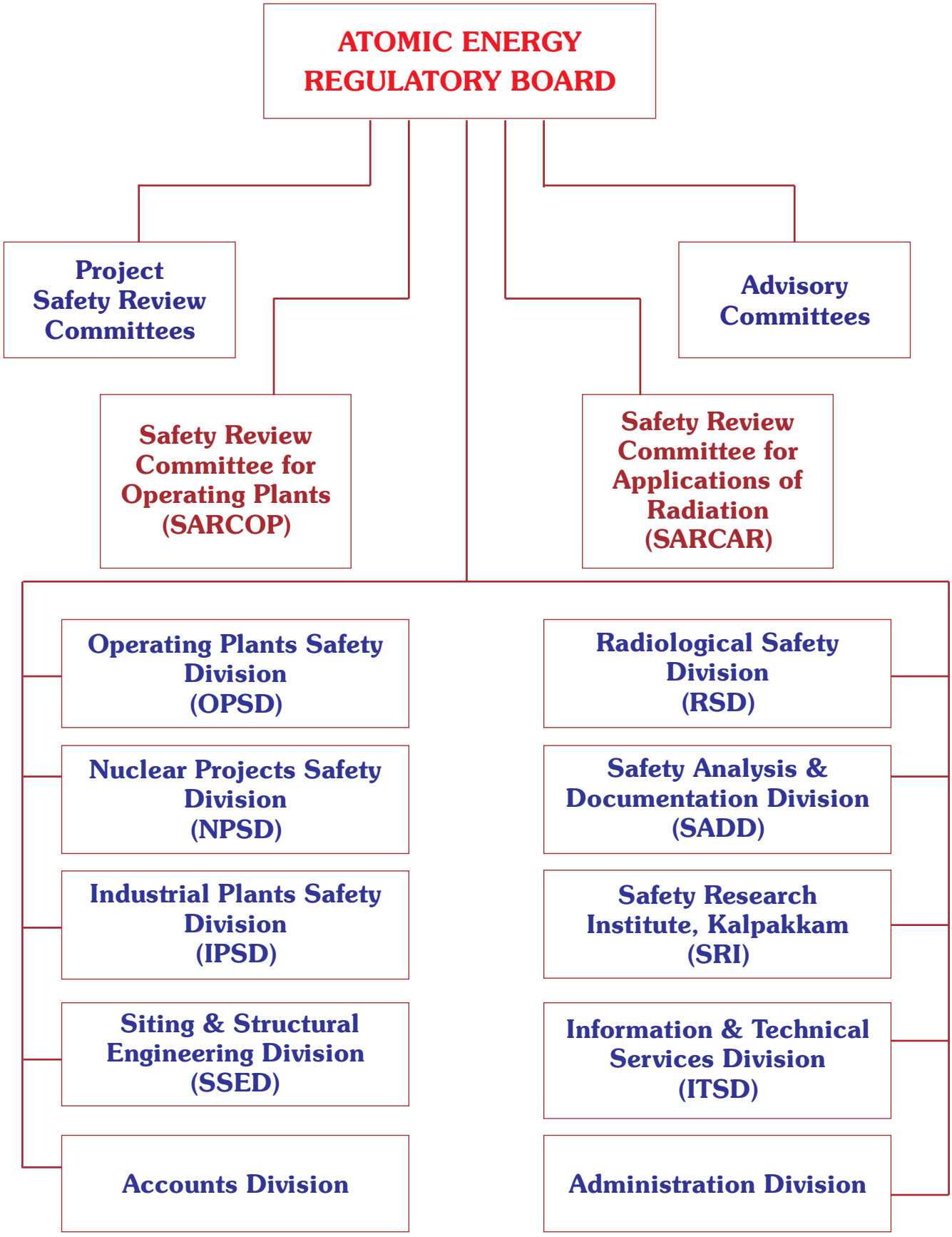
1.	Shri S.S. Bajaj, AERB	…	Chairman
2.	Shri S.K. Chande Vice-Chairman and Chairman, SARCOP, AERB	…	Member (Ex Officio)
3.	Dr. K.V. Raghavan INAE Distinguished Professor Indian Institute of Chemical Technology Hyderabad	...	Member
4.	Prof. J.B. Joshi DAE Homi Bhabha Distinguished Chairperson & Former Director Institute of Chemical Technology Mumbai	…	Member
5.	Dr. K.A. Dinshaw Former Director Tata Memorial Centre, Mumbai	…	Member
6.	Shri R. Bhattacharya Director, Information and Technical Services Division and Director, Industrial Plants Safety Division, AERB	…	Secretary

1.2 ORGANISATION CHART OF AERB



1.3 SUMMARY

As on March 31, 2011, there are 20 operating units of nuclear power plants (NPPs), 6 units under construction and 1 unit under commissioning. The operating fuel cycle facilities and research centres comprise: 7 Heavy Water Plants (HWP), 4 Indian Rare Earths Limited (IREL) plants, 3 major research centres, 6 uranium mines and 2 uranium mills, Nuclear Fuel Complex (NFC), Hyderabad and Zirconium Complex at Palayakayal. A uranium mill at Tummalapalle and Technology Demonstration Plant (TDP) of Heavy Water Board (HWB) at Chembur for extraction of uranium from secondary sources are under construction and 3 new uranium mines are in the development stage.

AERB carried out its functions with the support of its secretariat and specialist committees under the guidance of the Board. The Board met four times during the year: on April 23, 2010, November 4, 2010 and March 23, 2011 at Mumbai and during February 3-4, 2011 at Kudankulam (KK). During the meeting at Kudankulam, the members visited KK-1&2 construction site.

During 2010-11, AERB carried out its mandated functions and responsibilities with the support of its secretariat and specialist committees under Board's guidance.

AERB Board Meeting in Progress at AERB
(AERB Board Members Shri S. S. Bajaj, Shri S. K. Chande, Dr.K.V. Raghavan, Prof.J.B.Joshi, Dr.K. A. Dinshaw, Shri R. Bhattacharya are seen in the picture along with Senior Officials)

Regulatory Actions by AERB following Mayapuri Scrapyard Incident at Delhi

At the beginning of the financial year i.e. in April 2010, the nation witnessed a radiological incident that occurred in a metal scrap market at Mayapuri area of Delhi. The incident resulted in one death and radiation overexposure to six persons. Following this incident, AERB launched vigorous campaigns on several fronts to strengthen the regulatory control on the large number of radiation facilities operating in the country. Some of the major steps taken by AERB included intensive campaigns to discover any remaining legacy sources, computerization of inventory of sources, increased inspections of radiation facilities, conducting awareness programmes etc. This has brought considerable improvement in the regulation of radiation application sector.

Safety Review of Nuclear Power Projects

During this period, AERB not only strengthened its regulatory control over the radiation facilities, but also continued to carry out its mandated activities ensuring that the regulatory and safety requirements are met. Extensive review was carried out for different commissioning stages of Rajasthan Atomic Power Project, units-5&6 (RAPP-5&6) at Rajasthan, namely, heavy water filling of primary heat transport (PHT) system, raising of reactor power in stages upto 100% full power and clearances were issued. Clearances for initial fuel loading, heavy water addition to moderator and PHT systems and first approach to criticality for Kaiga Generating Station, unit-4 (KGS-4) at Kaiga were also issued after detailed review.

For the indigenously designed first twin unit stations of 700 MWe PHWRs at Kakrapar, AERB issued clearance for 'First Pour of Concrete'. For the second twin unit stations at Rajasthan, RAPP-7&8, siting consent and excavation clearances were issued.

Major civil construction activities and erection of major equipment for Kudankulam Nuclear Power Project, units-1 &2 (KK NPP-1&2) at Kudankulam, each of 1000 MWe VVERs have been completed. For KK NPP-1, hydro-tests of primary coolant system and secondary system, proof test and integrated leakage rate test (ILRT) of primary containment and containment spray test were carried out and the test results were assessed to have met respective design intents. Dummy fuel assemblies and control and protection system absorber rods (CPSAR) have been loaded in the reactor pressure vessel and the same is boxed up. For starting 'hot-run' of KK NPP-1, preparation by site and safety review by AERB are in progress.

Siting consent for locating 4 additional units, each of 1000 MWe VVERs, KK NPP-3 to 6, near KK NPP -1&2 were granted after the required safety review as per the established regulatory process.

Construction and erection activities are in progress for indigenously designed sodium cooled Prototype Fast Breeder Reactor (PFBR) of 500 MWe capacity.

AERB strengthened its regulatory control on the large number of radiation facilities in the country post the radiological incident in Mayapuri area of Delhi.

AERB initiated several steps such as intensive campaigns to discover any remaining legacy sources, computerization of inventory of sources, increased inspections of radiation facilities, and conducting awareness programmes.

After multi-tier safety reviews, clearances for initial fuel loading, heavy water addition to moderator and PHT systems and first approach to criticality for KGS-4 was issued.

NPCIL is planning to install progressively 6 units of European Power Reactor (EPR), each of 1650 MWe Pressurised Water Reactor (PWR) (Vendor M/s. Areva, France) at Jaitapur site on the western coast in the state of Maharashtra. NPCIL's application seeking siting consent for these units is under review by Site Evaluation Committee (SEC). Ministry of Environment and Forests (MoEF) had accorded the environmental clearance for the site, subject to AERB consent.

Safety review of three nuclear fuel cycle facilities namely, Demonstration Fast Reactor Fuel Reprocessing Plant (DFRP), Interim Fuel sub-assembly Storage Building (IFSB) and Fast Reactor Fuel Cycle Facility (FRFCF) designed by IGCAR is continuing.

AERB expanded the scope of its regulatory inspections to include security of nuclear facilities in addition to the existing one which covers nuclear, radiation and industrial safety from this year onwards.

Accordingly three security inspections were carried out during the year, one each for Kakrapar Atomic Power Project (KAPP-3&4), KGS-4 and RAPP-5&6. Apart from the above, 1 special inspection and 16 regular inspections were carried out for NPP project sites. In addition to regular inspections, monthly inspections covering industrial safety aspects were also carried out for all NPP project sites.

Safety Review of Operating NPPs and Research Reactors

All NPPs and research reactors operated safely during the year. At the beginning of the year, Narora Atomic Power Station (NAPS-2) and Kakrapar Atomic Power Station (KAPS-1) were under long shutdown for en-masse coolant channel replacement campaigns. A number of applications related to various stages of restart of these units were received in AERB. After detailed review of these applications and based on the satisfactory performance of the units at various stages of restart, stage-wise clearances were given for continuous operation of these units.

The report on applications for renewal of authorisation of Madras Atomic Power Station (MAPS-1&2) and Tarapur Atomic Power Station (TAPS-1&2) were reviewed in detail. These reviews indicated that the operational safety performance of these plants has been satisfactory during the reporting period. However, pending the review of reassessment of safety and emergency mitigation measures at these NPPs, in wake of the accidents in Fukushima NPPs, the license for operation of these units was extended only upto June 30, 2011 and September 30, 2011 respectively.

As brought out in the report for the year 2009-10, during the review of application for renewal of license for operation of KAPS, certain issues were identified which needed to be resolved before the license could be renewed. After satisfactory resolution of these issues, the license for operation of KAPS was extended upto July 31, 2014.

AERB expanded the scope of regulatory inspections by including the nuclear security aspects.

All nuclear power plants and research reactors operated safely during the year.

During the year, a total of 34 significant events were reported from operating NPPs, out of which 33 were rated at International Nuclear Event Scale (INES) Level-0. One event, involving radiation exposure of a worker beyond the annual exposure limit, was rated at INES Level-1.

The radioactive releases from NPPs were within the limits of technical specifications for operation.

A total of 31 regulatory inspections were conducted for operating plants during the year which included 5 security inspections. Regular inspections covered radiological and nuclear safety aspects in addition to industrial safety.

Safety Review of Fuel Cycle Facilities, R&D and Other Facilities

All nuclear fuel cycle and Research & Development (R&D) facilities operated safely during the year. Major consents issued in nuclear fuel cycle facilities include: siting of Uranium Ore Processing Plant and Tailings Management Facilities of UCIL at Gogi, Karnataka, construction of Tummalapalle Mill and 'Tailings Dam and Pond' of UCIL at Tummalapalle and operation of Bagjata mine.

Major consents issued for R&D facilities included: commissioning of super conducting cyclotron (K-500) machine till stage – VI (i.e transportation of the beam to Channel-3 of cave-2) of VECC, Kolkata and operation of beam lines BL-8, BL-11 and BL-12 at INDUS-II, commissioning of 150 Terra Watt: Ti- Sapphire Laser system at Raja Ramanna Centre for Advanced Technology (RRCAT), Indore and commissioning of stages 3, 4 and 5 of 10 MeV FEL Linear Accelerator (LINAC) in INDUS-I building at RRCAT, Indore.

For nuclear fuel cycle, R&D and other facilities, a total of 50 regulatory inspections were conducted during the year, which also included industrial safety aspects.

Industrial Safety

Applications for renewal/ issue of licenses for operation of various DAE units were reviewed and licenses under the Factories Act were renewed/issued to HWPs- Manuguru, Talcher & Kota, Turamdih & Jaduguda mills of UCIL and ECIL, Hyderabad.

There were 3 fatal accidents at construction sites of the DAE projects; 2 at Kudankulam Nuclear Power Project and 1 at PFBR, BHAVINI, Kalpakkam. Regulatory inspections for industrial and fire safety aspects were strengthened at project sites. Job hazard analysis (JHA), preparation of safe working procedures and use of field check list on JHA were made mandatory for all hazardous works at sites.

Apart from the regular inspections of nuclear power projects, operating NPPs, fuel cycle, R&D and other facilities, additional 43 industrial safety focused monthly inspections at construction sites of nuclear power projects and 5 quarterly inspections of fuel cycle facilities construction sites were carried out.

A total of 31 regulatory inspections were conducted for operating plants during the year which included 5 security inspections.

Forty-three industrial safety-focused monthly inspections at various construction sites of NPPs and 5 quarterly inspections of fuel cycle facilities construction sites were carried out during the year.

Safety Surveillance of Radiation Facilities

AERB issued license for operation of 3 medical cyclotrons and 2 industrial gamma radiation processing facilities during January - December 2010. With this, there are now 12 medical cyclotrons and 17 industrial gamma radiation processing facilities in India. Over 2945 licenses were issued for procurement of radiation sources, 33 licences for procurement of linear accelerators and 268 authorizations were issued for export and disposal of sources.

A total of 521 certificates of registration were issued to diagnostic X-ray installations. Forty one permissions were issued for transport of radioactive material other than disposal. Five shipments were approved to be transported under special arrangement.

AERB conducted regulatory inspections in various radiation facilities and investigated 3 unusual occurrences related to loss or misplacement of radiation sources.

AERB conducted awareness programmes for regulatory requirements and radiation safety in fields of interventional radiology, nuclear medicine, planning of radiotherapy installations, dosimetry aspects for radiation processing facilities, radioactive contamination in steel products, safe handling of radioactive material, etc.

AERB adopted a graded approach for inspection of radiation facilities which led to a multifold increase in the regulatory inspections of radiation facilities. An important regulatory document 'Consenting process of radiation facilities' was published during the year which lays down the regulatory requirements for consenting stages for various radiation facilities such as medical cyclotrons, particle accelerators, irradiators, radiotherapy facilities etc.

Developmental Activities

AERB took steps towards incorporating state of the art technologies in carrying out its regulatory functions. AERB has taken an initiative to implement AERB-RSD information system (ARIS), a web-based information and communication technology (ICT) application for the automation and real time management of "Consenting Process" i.e. issue of licenses and regulatory clearances to various radiation facilities and other key stakeholders across the country. Corporate Human Asset Resource Management System (CHARMS) has been successfully implemented in AERB. Several meetings were conducted with utilities through video conferencing.

Apart from the mandated activities, AERB made progress in carrying out R&D and safety related studies. Many important developmental studies were taken up and completed. Papers were presented in national and international conferences, seminars etc. Some of the AERB officials successfully completed their higher studies such as PhD and M.Tech. AERB continued to fund several research projects undertaken at various universities and academic institutions under the CSRP scheme.

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AERB made progress in R&D and safety related studies

International Cooperation

The ongoing interactions with International Atomic Energy Agency (IAEA) and the regulatory bodies of USA, France and Russia continued.

Chairman, AERB led the Indian delegation and presented the national report of India on the Convention on Nuclear Safety (CNS) during the 5th review meeting of the convention at Vienna. The Indian National Report was very much appreciated.

AERB interacted with French safety authority (ASN) and French Institute for Radiological Protection and Nuclear Safety (IRSN) and has signed MoUs with ASN and IRSN for exchange of information.

Human Resource Development

Indian nuclear power industry along with associated fuel cycle facilities is undergoing significant expansion. In addition, there is a substantial increase in the use of radiation for societal benefits. To meet the regulatory challenges arising out of these expansions, AERB has augmented the technical manpower substantially by direct recruitment, inducting postgraduates through AERB Graduate Fellowship Scheme (AGFS) at IIT-Bombay and IIT-Madras, and through training schools of BARC, IGCAR, NPCIL and NFC. Consequently, the manpower in AERB has increased from 211 to 251 during the last year.

Various training programmes were arranged for the engineers and scientists of AERB. One refresher course and several technical talks were organized on various topics of interest. Orientation Course for Regulatory Processes (OCRP-2011) was conducted during January to March, 2011 for the scientists / engineers newly inducted in AERB. The course covered important topics related to functions of AERB, nuclear and radiation safety. Site visits to nuclear reactor/radiation facilities sites were also organized as part of OCRP-2011.

AERB's Self Assessment against IRRS

AERB has initiated an exercise to carry out a self assessment based on methodology and procedure used for integrated regulatory review service (IRRS) of IAEA. IRRS is a peer review service which compares the nuclear and radiation regulatory infrastructure in a State against international standards and good practices and brings out the strengths and areas of improvements. Towards this objective, a committee has been constituted for internal assessment of preparedness of AERB for IRRS of IAEA. The committee is using online Self Assessment Tool (SAT) from the website of IAEA for self assessment of national regulatory infrastructure of AERB against IAEA safety standards. Based on the internal analysis, an improvement plan will be derived and implemented by AERB within the legal framework of the country.

Measures Taken by AERB Post FUKUSHIMA Nuclear Accident in Japan

As the year 2010-2011 was coming to a close, an unprecedented earthquake and

AERB took the initiative to evaluate its preparedness for integrated regulatory review service (IRRS).

AERB interacted with French safety authority (ASN) and French Institute for Radiological Protection and Nuclear Safety (IRSN) and has signed MoUs with ASN and IRSN for exchange of information.

tsunami simultaneously hit the eastern coast of Japan on March 11, 2011. This led to serious damage at the Fukushima Daiichi NPPs and resulted in release of radioactivity from the NPPs.

Considering the gravity of the accident, AERB acted swiftly and closely monitored the events unfolding at the Fukushima Daiichi NPPs. AERB convened a Board meeting on March 23, 2011 to take stock of the situation vis-à-vis safety of Indian NPPs. The Board members were apprised of the accident and status of the Fukushima plants, and also about the safety provisions provided in Indian NPPs. The Board reviewed future course of action for ensuring safety of Indian NPPs in the light of the Fukushima Plant.

AERB has constituted a high level committee under the chairmanship of Shri S. K Sharma, former Chairman, AERB and experts from various national institutes to assess the preparedness of the existing NPPs in India to deal with a situation arising out of a natural disaster. The committee will review the safety provisions of existing NPPs including storage of spent fuel at all NPP sites. The committee has constituted various working groups for in-depth review of the safety provisions specific to Indian NPPs to handle Fukushima type scenario as well as other possible accident scenarios initiated by external events.

AERB has formed an in-house monitoring cell to constantly follow and monitor the events at Fukushima NPP and coordinate with technical support organizations (TSO) to collect information on radiation levels, contamination levels in air, water and soil at regular intervals, so as to evolve necessary guidance as required in the evolving situation.

The information of radiation levels prevailing at various locations in India were updated on AERB's website on a daily basis. AERB has also identified three institutions in India for analysis of radioactive contamination in food samples, if any. After review, AERB felt that screening of persons coming from Japan to India for contamination was not required at that time.

During the entire period, AERB has maintained constant interaction with the media and press and public has been kept informed on the situation through press releases and updates on AERB website.

Through IAEA, a team of fact finding international nuclear safety experts from 12 countries including India, conducted a preliminary mission by visiting the accident site in Japan. Shri S.K. Chande, Vice-Chairman, AERB was the Indian representative in the team.

AERB acted swiftly and closely monitored the events unfolding at the Fukushima Daiichi NPPs.

The AERB Board reviewed the existing safety provisions in Indian NPPs and future course of action in the light of the Fukushima Plant.

AERB initiated a number of measures following the Fukushima nuclear accident. This included constitution of a high level committee of experts from relevant fields to assess the preparedness of the existing NPPs in India to deal with a situation arising out of severe natural disasters.

CHAPTER 2

SAFETY SURVEILLANCE OF NUCLEAR FACILITIES

2.1 MEASURES TAKEN POST FUKUSHIMA NUCLEAR ACCIDENT IN JAPAN

An unprecedented earthquake and tsunami simultaneously hit the eastern coast of Japan on March 11, 2011. This led to serious damage at the Fukushima Daiichi NPPs and resulted in release of radioactivity from the NPPs.

AERB closely monitored the progression of events based on the information through various agencies, such as IAEA, NEA, NISA, etc and also through media reports.

AERB convened a Board meeting to review the safety of Indian NPPs vis-à-vis the event at Fukushima NPP. The Board members were apprised of the accident and status of the Fukushima plants, and also about the safety provisions existing in Indian NPPs for prevention of accidents of that nature. AERB Board reviewed future course of action for ensuring safety of Indian NPPs.

There were public concerns about the impact of this accident on environmental conditions in India due to the radioactivity releases from Fukushima NPPs.

Considering the geographical location of India with respect to Fukushima, Japan and the prevailing wind conditions towards the east direction and also based on detailed internal review, AERB concluded that there would not be any radiological impact in India due to the radioactivity release from Fukushima, Japan. To confirm this and to rule out any adverse impact, AERB kept a constant vigil on the online radiation data at 28 locations across the country provided by Indian Environmental Radiation Monitoring Network (IERMON). As expected, there was no increase in the radiation levels above normal backgrounds at any location. This information was regularly uploaded on the AERB website to allay undue fears that might arise in the public.

In the context of this accident, it is recalled that for Indian NPPs due care is taken to locate them away from areas having major seismic activity. AERB ensures that the designs of the NPPs incorporate adequate margins and provisions against such natural events of specific magnitude, which are based on conservative criteria. Some of the older plants (TAPS-1&2, RAPS-2 & MAPS-1&2) were designed for seismic considerations prevalent at that time. Subsequently, these units were re-evaluated with respect to the site specific acceleration levels. Based on the findings, some of the structures, systems and components were strengthened. These modifications included provision of new emergency diesel generator buildings, anchoring of battery banks and control room panels, strengthening of masonry walls, strengthening the supports for cable trays and ventilation ducts, etc.

Following the Fukushima accident, AERB has asked Nuclear Power Corporation of India Limited (NPCIL) to carry out a comprehensive reassessment of safety against external events and emergency mitigation measures at all the NPPs. The license for operation of TAPS-1&2 and MAPS-1&2 were valid till March 2011 and December 2010 respectively. NPCIL had submitted the applications for renewal of license for operation of these units for the next five years. Pending the reassessment of safety and emergency mitigation measures at these NPPs, the permission for operation of these units were limited to June 2011 and September 2011 respectively.

AERB has taken several measures post the Fukushima Nuclear Accident as given below:

2.1.1 AERB constituted a high level committee under the chairmanship of Shri S. K. Sharma, former Chairman, AERB comprising experts from Central Water and Power Research Station, Indian Institute of Tropical Meteorology & IIT (Madras) apart from BARC, NPCIL & AERB to review

- The capability of Indian NPPs to withstand earthquakes and other external events such as tsunamis, cyclones, floods, etc.
- Adequacy of provisions available to ensure safety in case of such events, both within and beyond design basis.

The committee has sought plant specific details from the utility including available safety provisions to handle the Fukushima type scenario as well as other possible accident scenarios initiated by external events. These details are undergoing critical review by working groups constituted by the committee.

2.1.2 An in-house monitoring cell was constituted to follow the events at Fukushima continuously and keep a close vigil on the radiation/contamination levels in Japan and India.

2.1.3 AERB website was updated on daily basis regularly

- Radiation levels recorded by IERMON encompassing whole of India

- Report of the monitoring cell on the reactor parameters such as reactor pressure, feed water nozzle temperature, temperature of the bottom head, primary containment vessel pressure of the four units of Fukushima Daiichi, the occupational exposure to workers, radiation and contamination levels at different prefectures of Japan.

2.1.4 AERB issued press releases as given below.

- March 15, 2011 (to give assurance that all the reactors in India are designed to withstand the earthquake and tsunami of specific magnitude based on conservative criteria and programme to carry out comprehensive reassessment of safety and emergency mitigation measures at all Indian NPPs)

- March 17, 2011 (to inform that there is no radiological impact in India from Fukushima incident as of then)

- March 28, 2011 (to inform action by AERB post Fukushima incident).

2.1.5 AERB informed the Food Safety and Standards Authority of India (FSSAI) that there are three laboratories in India identified for testing of food items for contamination. AERB representative attended the meeting organized by FSSAI for taking a decision related to import of food items from Japan.

2.1.6 AERB assessed the need for any additional requirement for screening of passengers from Japan and informed National Disaster Management Authority (NDMA) that there was no such requirement at that time.

2.1.7 Chairman, Vice-Chairman and Secretary, AERB issued statements at regular intervals addressing the concerns from journalists and electronic media regarding safety of Indian NPPs and also the impact of Japan incident.

2.1.8 Through IAEA, a team of international nuclear safety experts from 12 countries including India, conducted a preliminary mission to find the facts and identify the lessons from the accident. Shri S.K. Chande, Vice-Chairman, AERB was the Indian representative in the team.

Shri S. K. Chande, Vice-Chairman, AERB along with International Team of Experts for deliberations on Fukushima Incident in Japan

2.2 NUCLEAR POWER PROJECTS

2.2.1 Project Safety Review

AERB has been following a well-established practice of multi-tier review process for safety review of nuclear projects starting from siting through commissioning stages. The Site Evaluation Committee (SEC), Project Design Safety Committee (PDSC), Civil Engineering Safety Committee (CESC) and associated Specialist Groups (SGs)/Working Groups (WGs)/Task Forces (TFs), carry out the first-tier review. For KK NPP units-1 & 2, an in-house KK Co-ordination Group (KK-CG) along with SGs carried out the first-tier design safety review.

The corresponding Advisory Committee for Project Safety Review (ACPSR), which includes specialist members from the Ministry of Environment and Forests, Central Boilers Board, Central Electricity Authority and Educational Research Institutes, experts retired from DAE units and members from BARC/IGCAR/NPCIL and AERB perform the second-tier review.

The third-tier review is carried out by the AERB Board. The safety review process is augmented by periodic regulatory inspections as per the established practice for verifying compliance with the requirements recommended by the safety committees and those specified in various codes, guides and standards of AERB.

AERB has circulated draft proposal for implementing event reporting system during construction/commissioning phase of NPPs to NPCIL-HQ and all the project sites for their comments/suggestions.

Table 2.1 lists the number of meetings held by various safety committees during the year. In addition, a large number of meetings of SGs, TFs and WGs constituted by SEC/PDSC/CESC/ACPSR/AERB were held for in-depth review of specific aspects of the projects.

Table 2.1: Safety Review Committee Meetings of Nuclear Power Projects and Backend Nuclear Fuel Cycle Facilities

Project Safety Committee	Number of Meetings
ACPSR-LWR - 1 (KK 1&2)	6
ACPSR LWR - 2 (New Projects)	1
ACPSR-PHWR 8	8
PDSC-KGS-3&4 and RAPP-5&6	12
PDSC-KAPP-3&4 and RAPP-7&8	15
SEC-700 MWe PHWRs	2
PDSC-KK NPP 3&4	2
PDSC-PFBR	1
PDSC-DFRP	2
SEC-KK NPP 3 to 6	2
SEC-JNPP	2
WG-TA-JNPP	10
CESC	12

The status of safety review of various projects and important observations and recommendations during the review are given in the following paragraphs:-

(i) KGS-3&4 & RAPP-5&6

KGS-3&4 and RAPP-5&6 are repeat designs of standardized 220 MWe PHWRs with minor differences, mainly in plant layout and control & instrumentation systems. Multi-tier review of NPCIL's applications seeking clearances for different commissioning sub-stages of KGS-4 and RAPP-5&6 was carried out progressively as per the established process and issues emanated were satisfactorily resolved prior to issuance of clearances by AERB.

(ia) KGS-4

KGS-4 achieved first criticality on November 27, 2010. Subsequently, various commissioning activities namely Phase-B tests, synchronization of the unit to power grid for the first time on January 19, 2011, raising of reactor power to 90% full power (FP) in stages and related performance tests were carried out.

Some of the salient observations/ recommendations made during safety review are given below:

- Based on the observation made during plant walk-through, the cables were relocated or fire retardant coating was applied on the cables at locations where physical gap between cables and high enthalpy pipe lines was less than the required gap of 50 mm,. Surveillance programme for checking healthiness of fire retardant coatings on the cables at these locations was established.

- TF constituted by NPCIL carried out plant walk through for implementation of design requirements for laying of power and control cables and corrective actions were implemented. Seismic walk down at the plant was also carried out by NPCIL TF and corrective actions were taken, as found necessary. Recommendation reports of these TFs along with compliance status on their recommendation were further reviewed by PDSC.

- Dent marks on 'E' faces of coolant channels were rectified prior to filling of PHT system with heavy water.

(ib) RAPP-5&6

Clearance for raising reactor power to 100 % FP for RAPP-5 was granted after satisfactory review of the results of mandatory tests carried out at 90 % FP. The application for continuous operation of RAPP-5 is under review. For RAPP-6, clearances for raising reactor power to 90 % FP and then to 100 % FP were granted after satisfactory review of the results of mandatory tests carried out at 50 % FP and 90 % FP respectively. Both RAPP-5 and RAPP-6 are being operated at 100% FP.

Some of the salient observations/ recommendations during safety review are given below:

- During first week of April, 2010, water seepage of ~ 1.5 litres per day was observed near the spare seal plug storage rack support through a wall of south fueling machine service area of RAPP-5. The presence of Li and Zn-65 in seepage water indicated that the seepage water was from calandria vault. Sampling was carried out to check for high content of Na and K in the seepage water and it was confirmed to be leaching out from the concrete. The seepage rate has reduced to ~ 250 ml/day by March 2011. Action plan for leak identification and rectification is being worked out.

- In RAPP-5, during the adjuster rod position adjustment, automatic liquid poison addition system (ALPAS) got actuated as per the logic on sensing shim rods not fully out and the relevant motorized valves (MVs) of the system got opened but these MVs did not close back due to persistence of reactor regulating system (RRS) signal. This resulted in injection of neutron poison from ALPAS tank into the moderator

system for a long time and eventually resulted in tripping of reactor.

The safety review of this incident called for a modification in the software used in dual control hot standby (DCHS)-RRS. Reactor start up was permitted after a thorough safety review of the incident. Modified RRS software was also implemented in KGS-3&4 and RAPP-6.

In this context, it was recommended to the designer to verify that there is no deficiency in any of the safety related computer based systems (CBS) of a kind that existed and revealed in RRS software of RAPP-5. In line with this recommendation, assessment of DCHS-Process Controlled Systems (PCS) software was carried out by the designers and no weakness, as observed in DCHS-RRS, was noticed.

- RAPP-5 was shutdown on June 17, 2010 to investigate the cause for increase of radiation fields in the south F/M vault and service area. The cause was traced to be air ingress into end-shields. To overcome the problem, layout of end-shields vent lines was modified to achieve proper venting. Radiation fields in these areas reduced considerably and reactor was started back. Based on this experience, vent lines of north and south end-shields were separated and were connected to expansion tank independently in RAPP-6.

- RAPP-5 reactor was tripped manually on July 16, 2010 as tritium in active process water system increased to 5000 Bq/ml. Fuelling machine return cooler was found to have leaky tubes. 14 tubes were plugged and the secondary side process water flow was decreased to reduce flow induced vibration of tubes after assessing adequacy of revised flows through the heat exchanger. Considering this experience, eddy current testing (ECT) of fuelling machine return cooler tubes of RAPP-6 was carried out prior to filling of system with heavy water and 20 tubes were plugged.

(ii) KK NPP-1&2

KK NPP consists of two units of 1000 MWe VVER of Russian design. For KKNPP-1, commissioning activities are in progress. For commissioning phase, additional SGs and TFs (SG-Commissioning Aspects, SG-Reactor Physics, SG-Fuel Handling System, TF-Containment Tests, and TF-PSI/ISI) have been constituted to perform in-depth review. Dummy fuel assemblies were loaded in the reactor pressure vessel. Hydro tests for primary coolant system and secondary circuit were performed. The proof test and integrated leakage rate test (ILRT) of the inner containment structure of unit-1 of KKNPP was carried out as per the approved procedure in presence of AERB representatives. The results indicated satisfactory performance of containment structure. AERB also reviewed the documentation of construction completion certificate (CCC) for safety related civil engineering structures of KKNPP and suggested measures for improvement in the documentation and retrievability of information.

ACPSR-LWR Members in Main Control Room of KKNPP

Containment spray test was carried out. All four emergency diesel generators (DGs) have been load tested up to the rated capacity by connecting to grid. 400 KV gas insulated switchyard (GIS) has been charged through two feeders. Generator transformer (GT) and both unit auxiliary transformer (UATs) charged. Shop testing of Control and Protection System Absorber Rod (CPSAR) drives was completed. 115 CPSAR drives installed in position and operability checks were completed from main control room (MCR). Site and Plant emergency preparedness plans (EPPs) have been approved by SARCOP.

Some of the salient observations/ recommendations during safety review are given below:

- NPCIL was asked to submit detailed response to various observations made on cable layout with regard to adequacy of space for inspection maintenance, heat dissemination, etc. along with justification for deviations from established methods of laying of cables and alternative measures to meet any exigencies.

- AERB agreed to site's proposal to conduct leak testing of transport air lock subsequent to containment tests after necessary repairs.

- For the computer based systems that have undergone factory validation, NPCIL has planned to perform site validation. Reports on site validation will be audited by an expert group of AERB.

- AERB has recommended that the performance of leak monitoring system incorporated in the design as part of 'leak before break' (LBB) criteria should be demonstrated during commissioning phase.

(iii) Prototype Fast Breeder Reactor (PFBR)

Construction and erection activities are in progress for indigenously designed sodium cooled PFBR of 500 MWe capacity. Core support structure, grid plate, inner vessel, etc. have been erected inside the main vessel. Preparations for erection of roof slab are in progress.

81 consignments (~ 1470 Te) out of total 1750 Te sodium have been unloaded into the sodium storage tanks.

Some of the salient observations/ recommendations made during the safety review are given below:-

- Revised estimation by considering the vortex formation in the sodium free level in inner vessel indicated higher entrainment of the Argon cover gas than the previous estimation. A baffle of 500 mm size was introduced inside the inner vessel based on the experiments made in the 1/4th model of the vessel to reduce the vortex formation. This design change was accepted after review.

- Locking of bolts for integrating the grid plate and spherical header to the core support structure was done by tack welding during the implementation stage instead of introducing split pin as per the design envisaged earlier. Considering that these components are inaccessible for maintenance subsequent to reactor start up, it was suggested to go for full weld or else to get the tack weld metallurgically qualified. Subsequently, all the tack welds were qualified metallurgically.

- Designers are planning to provide only one rupture disc (RD) at either end of each steam generators (SG) in the light of reliable operation of RDs in FBTR and the international experience. It was further observed that FBTR RDs have not seen the design temperature and hence its reliability cannot be assessed based on the present performance. Subsequently, justification note on providing only one RD was submitted for review and it was observed that single RD is more reliable from safety point. The same may not be true for availability of SG, as spurious failure of RD may result in non-availability of SG.

- AERB reviewed the aspects related to modified scheme for the support arrangements of SGs submitted by PFBR. The scheme was found acceptable.

- Regulatory inspection of PFBR had revealed certain quality related observations related to civil engineering construction. These observations were discussed in safety committee meetings and appropriate action to improve the quality of construction was recommended.

Placing of roof slab in the reactor vault for alignment checking

(iv) KAPP-3&4 and RAPP-7&8

KAPP-3&4 project is the first 700 MWe Indian PHWR designed to achieve higher power (700 MWe compared with 500 MWe in previous design), by allowing partial boiling in coolant channels. It also incorporates several new safety features such as passive decay heat removal system, steel lined containment and containment spray system. Detailed design of 700 MWe PHWRs is in progress. Clearance for first pour of concrete (FPC) for KAPP-3&4 was issued on November 20, 2010. Construction activities are in progress for KAPP-3&4.

The design of RAPP-7&8 is similar to KAPP-3&4, except for site specific changes. For RAPP-7&8, AERB issued siting consent and excavation clearance on May 24, 2010 and August 18, 2010 respectively. Excavation work for main plant island is in progress. Safety review towards granting FPC clearance is in progress.

Construction of KAPP-3 RAFT

Design safety review of 700 MWe PHWR continued during the year based on PSAR sections submitted by NPCIL. Some of the salient observations/recommendations made during the safety review are given below:-

- For first of a kind (FOAK) systems, such as, regional over power protection (ROPP), passive decay heat removal system (PDHRS), primary containment spray system (PCSS), mobile transfer machine (MTM), tritiated liquid waste discharge to air through ventilation stack by evaporation route, steel lined primary containment, interleaving feeder layout, etc., NPCIL has been asked to submit periodic reports of progress on experiments/ analyses/ R&D activities to facilitate in-depth review.

- Documents related to design basis ground motion (DBGM) parameters and estimation of design basis flood level (DBFL), seismic analysis reports for major safety related structures, design reports, construction methodology and project quality plan were reviewed. DBGM parameters for KAPP were accepted after detailed review and discussions with the experts. DBFL for KAPP was accepted with certain recommendations like:

  - Construction of an additional waste weir.
  - Setting up alarm in main control room for KAPP- 3&4, for high water level in Moticher lake.
  - Periodic monitoring of Moticher lake capacity and de-silting.

- Certain issues emanated during design safety review of end-shields, such as, use of borated steel in lattice tube region to reduce neutron dose rates in FM vault, studies/data collection related to dose contribution from coolant system header/feeders, measures to reduce dose in FM vaults during inspection and maintenance jobs, incorporation of sub-micron filters in PHT and moderator circuit to reduce dose rates, etc. are under detailed review.

- Interleaving of feeders is being implemented for the first time in PHWRs. Specific aspects of this design such as whip force analyses affecting other PHT loop, PHT feeders support finalization, adequacy of layout feeders and instrument tubing, neutronic coupling effect of voided channels on neighboring channels, etc. are under detailed review.

- Two phase instability in PHT main system due to temperature perturbation set in by refueling, the parallel channel flow instability potentials etc. are under review.

- Global concentration of hydrogen generated due to metal water reaction during severe accident scenario would not exceed 4 % V/V as per the estimation carried out by the designers and based on this it was inferred that separate measures for hydrogen management may not be required. This aspect is under detailed review taking into consideration non-availability of RB air coolers, effect of CSS spray on hydrogen mixing, stratification etc. under severe accident scenario.

- Pipe-whip load resulting from failure of main steam line (MSL) and feed water line (FWL) is of concern for design of primary containment. NPCIL confirmed that properly designed pipe-whip restraints of adequate capacity will be provided for MSL and FWL after completing detailed design of the system.

- Radiological impact assessment (RIA) under postulated events has been reviewed and NPCIL was asked to give clarifications on deposition behaviour of radio-nuclide inside containment, forms of iodine used in revised source term, considerations to be given for wash out effect, deposition velocity, time dependent Gaussian plume modelling. The source term may need revision, based on various observations made during review.

- Detailed review of spent fuel storage bay for storage capacity, cooling capability, adequacy of water inventory for decay heat removal on long term basis is in progress.

- Based on the meeting of national experts at AERB on April 5, 2010, it was concluded that no tectonically capable fault exists within 5 km radius of RAPP-7&8. As per the experts' opinion, micro earthquake (MEQ)

network needs to be installed at RAPP site for collection of seismic data.

- Refined analysis using heavy gas model is being performed for estimating concentration of H_2S at various distances during the postulated events those would result in release of H_2S from heavy water plant at RAPP site. Emergency preparedness plan would be revised accordingly.

- Liquid wastes of RAPP-7&8, having relatively higher concentration of tritium activity and less volume are proposed to be sent to existing solar evaporation facility (SEF) for slow air route discharge. Considering the experience with this earlier built SEF for design life of RAPP-7& 8 (say 60 years), procedure for condition monitoring of SEF is under review.

(v) KK NPP- 3 to 6

NPCIL proposes setting up four 1000 MWe VVER units in addition to the two units (KK NPP-1&2) under construction/commissioning. Environmental clearance from MoEF was received in September 2008 for KK NPP-3&4 and in December 2009 for KK NPP-5&6. Tamil Nadu State and District have recommended giving Coastal Regulation Zone (CRZ) Clearance for KK Site. AERB granted siting consent for KK NPP-3 to 6 on February 09, 2011. Safety review for excavation clearance of KK NPP-3&4 is in progress.

Some of the salient observations/ recommendations during the process of safety review are given below:-

- NPCIL has installed 8 wind mills within Kudankulam site boundary. AERB has recommended that the impact of these wind mills on KK NPP-3 to 6 needs to be studied in detail and findings should be reported to AERB for review.

- Absence of capable fault within 5 km radius from the plant is a requirement as per AERB Siting Code for NPPs. In this regard, data available with Oil and Natural Gas Corporation of India Limited was obtained and after examination of this data, it was inferred that there is no fault within 8 km from the project site.

- During the review, it was expressed that external events like earthquake, flood, cyclone, can initiate common cause failures (CCF) simultaneously in all operating units at site. For example, seismic event of considerably higher acceleration than that was considered in the design affected several units at Kashiwazaki-Kariwa plant in Japan. Collective radiological impact of an accident in several plants due to such CCF could be higher than that estimated for Design Basis Accident (DBA) of an individual unit. It was recommended that, to begin with, seismic PSA should be carried out to check the CCF effect due to earthquake and should be completed prior to initial fuel loading in the reactor vessel.

- It was recommended to include both probabilistic and deterministic justification on the topic related to low trajectory turbine missile zone.

- It was recommended that emergency preparedness manual for KK NPP-1&2 should be revised to take care of personnel working in KKNPP-3 to 6 during construction/ commissioning phases.

(vi) Jaitapur Atomic Power Project (JNPP)

NPCIL is planning to install, progressively 6 units of EPR, each of 1650 MWe PWR (Vendor M/s. Areva, France) at Jaitapur site on the western coast in state of Maharashtra. NPCIL's application seeking siting consent for these units is under review by SEC. The SEC has asked for more detailed information on several site related aspects. MoEF had accorded the environmental clearance for the site, subject to AERB consent.

(vii) Demonstration Fast Reprocessing Plant (DFRP)

DFRP is a forerunner of the reprocessing facility FRFCF, to close fuel cycle of PFBR, being setup by IGCAR at Kalpakkam. It is divided into 2 concrete cell facilities called head end facility (HEF) and process plant facility (PPF). Most construction/equipment installation and piping for the PPF have been completed at the time of construction of Kalpakkam reprocessing plant. Civil construction and equipment erection activities of HEF are in progress.

Some of the salient observations/ recommendations during the safety review are given below:

- Classification of events is based on the severity of consequence and probability of occurrence of event is not taken into consideration. This issue is under review.

- To prevent possibility of red-oil explosion, designers were asked to modify process system and related control and procedures.

- It was recommended to study consequences of fire in all radioactive areas and incorporate the design changes, as found necessary.

(viii) Interim Fuel sub-assembly Storage Building (IFSB)

AERB granted clearance for construction for IFSB in August, 2006. Civil construction of IFSB is nearing completion. Preparation for erection of equipment, procurement of various material, instrument, etc. is in progress. Commissioning of auxiliary systems and mechanical handling equipment is in progress.

2.2.2 Consents/Clearances/Permissions Issued

KGS-4

- Permission for light water draining from primary heat transport system of KGS-4 (July 15, 2010)
- Clearance for initial fuel loading, addition of limited quantity (20 Te) of heavy water in moderator system and heavy water filling of PHT system of KGS-4 (September 14, 2010)
- Permission for change in sequence: addition of 20 Te heavy water in moderator system for flushing before initial fuel loading at KGS-4 (September 20, 2010)
- Permission for changing initial fuel loading pattern for KGS-4 (October 9, 2010)
- Clearance for bulk addition of heavy water to moderator system of KGS - 4, (November 19, 2010)
- Clearance for First Approach to Criticality (FAC) for KGS - 4 (November 25, 2010)
- Clearance to conduct low power Phase-B Physics tests for KGS - 4 (November 27, 2010)
- Clearance for Phase-C commissioning (Synchronization of TG Set and Operation of Plant up to 50 % FP) for KGS - 4 (January 10, 2011)
- Clearance for raising reactor power to 90% FP for KGS-4 (January 28, 2011)
- Clearance for raising reactor power to 100% FP for KGS-4 (March 01, 2011)

RAPP-5

- Clearance for raising reactor power up to 100% FP for RAPP - 5 (May 24, 2010)

RAPP-6

- Clearance for raising reactor power up to 90% FP for RAPP - 6 (April 16, 2010)
- Clearance for raising reactor power to 100%FP for RAPP-6 (October 9, 2010)

KAPP-3&4

- Clearance for FPC for KAPP-3&4 (November 20, 2010)

RAPP-7&8

- Siting consent for RAPP-7&8 (May 24, 2010)
- Clearance for site excavation for RAPP-7&8 (August 18, 2010)

KKNPP-3 to 6

- Siting consent for KK NPP-3 to 6 (February 09, 2011)

2.2.3 Enforcement Actions

AERB has taken the following enforcement actions subsequent to review and inspection of NPPs.

- Hold on KGS-4 operation beyond 0.1% FP was imposed on December 01, 2010 till reason for rise in tritium content in the calandria vault water was established and the leaks rectified. This hold was revoked on January 10, 2011 after rectification of helium leak into calandria vault water and satisfactory review of the related reports.
- Hold on RAPP-5 start up was imposed on April 15, 2010 as reason for valves of ALPAS remaining open resulting in unwarranted addition of neutron poison to the reactor core was not established. This was revoked on April 23, 2010 after satisfactory review of the investigation report on malfunctioning of ALPAS.

2.2.4 Regulatory Inspections of Projects

Regulatory inspections (RI) of the on-going nuclear projects were carried out as a safety audit measure to ensure compliance with the AERB safety requirements and stipulations. The number of RIs carried out for various projects is given in Table 2.2.

Table 2.2: Regulatory Inspections of Nuclear Projects & Backend Facilities

Site	No. of Inspections
KGS - 4	1
RAPP - 5&6	1
KK NPP - 1 & 2	3
KK NPP - 3 & 4	1
PFBR	4
KAPP - 3&4	1
RAPP - 7&8	2
DFRP	2
IFSB	1
TOTAL	16

Apart from the above, one special inspection of RAPP-5&6 was carried out. Three security inspections were carried out for nuclear projects, one each for KAPP-3&4, KGS-4 and RAPP-5&6. Monthly inspections at construction sites of nuclear power projects were carried out to ensure industrial safety requirements.

Some of the important observations/ recommendations by RI teams are given below:

- Temporary shielding has been provided in RAPP-6 to arrest neutron streaming from FM vaults through the gap between FM vault walls and shielding doors. It was recommended that present arrangement needs to be reviewed by NPCIL and permanent solution to prevent neutron streaming should be engineered and implemented.

- In RAPP-5, cable tray was noticed to have been installed just above the LPIS tank having inadequate clearance between the tank and the tray. This would obstruct removal of float switches from the LPIS tank for maintenance, when need arises. It was recommended that the cable tray should be re-routed (similar to that done in Unit-6) to enable maintenance.

- In KK NPP-1&2, PHRS duct supports were found not matching with the EPs on secondary containment. It was recommended that if supports are not placed as per earlier design, then detailed analysis is to be carried out for assessing their structural integrity under safe shutdown earthquake (SSE) / operating basis earthquake (OBE) loads.

- In KK NPP-1&2, in liquid radioactive waste (LRW) area, wall concrete has been broken and re-bars frame were removed at many places. Site informed that nearly 60 Nos. of engineering change notices (ECNs) / design change notices (DCNs) exists for this area. The reason for design changes was due to change in the supplier of the process equipment for the system. It was recommended that safety implication for such changes in the civil structure should be studied and reports submitted to AERB for review.

- In KK NPP-1&2, on ECCS actuation signal, four pumps in each of the four trains of safety systems would start on auto. It is recommended to confirm by commissioning test with theoretical accounting for effect of high temperature of water as envisaged during accident condition that there is no possibility of gas locking of any of the pumps.

- In PFBR, deviations were noticed in the horizontality of roof slab support embedment after its erection. Inspection team has recommended to work out the solution to take care of these deviations and submit the same for review prior to erection of roof slab.

- In PFBR, DG sets are separated in all aspects to avoid failure of DGs due to a common mode failure. However the jacket cooling water expansion tanks of two DGs were found to be placed on the DG building rooftop without segregation. AERB has recommended to segregate each of the DG sets in all respects to avoid common cause failure. Also, there is a need to provide roof over jacket water expansion tanks to minimize unnecessary heating of water due to the sun.

- Off-site emergency exercise conducted in December 2010 at KAPS site did not cover the labour colony of KAPP-3&4, as the scenario considered for the exercise was not covering the sector wherein labour colony is located. Considering that the next off-site emergency exercise would be due only after 2 years and the construction activities are picking up at KAPP-3&4, it was recommended to check response of labour colony during emergency, on priority.

- It was observed that there are long continuous joints (almost across the diameter of excavated reactor building-7 on RAPP-7&8) traversing the pit base as well as pit walls. The joint was assessed by experts in the field. Based on their recommendations, water permeability test was done at the joints and necessary grouting was being carried out along the master joints as per procedure, before carrying out further construction. This issue is being reviewed further by the designers and AERB.

- At RAPP-7&8, the water samples from excavated areas of NB-7&8 were observed to contain H-3 concentration in the range of 80-130 Bq/l. This is surface run-off water due to rainfall/ seepage water flowing from the nearby waste management centralized facility (WMCF). It was recommended that

investigations are carried out to identify cause of H-3 concentration in seepage water and appropriate measures should be taken to avoid contamination at construction site.

- At many locations in DFRP, the off-gas header lines were observed to be blinded abruptly without smoothening the ends. This may lead to accumulation of radioactive materials at the blind end. It was recommended to carry out necessary modifications to prevent accumulation of activity at the blind ends.

- In IFSB, the uninterrupted power supply (UPS) was found to be placed inside the motor control centers (MCC) room. On a common mode failure like fire inside the MCC room, both Class III and UPS will not be available. It was recommended to relocate the UPS.

- It was recommended that all personnel posted at site including security staff inside exclusion zone (EZ) should be trained for emergency planning and preparedness for KKNPP-3 to 6.

2.3 OPERATING NUCLEAR POWER PLANTS AND RESEARCH REACTORS

2.3.1 Safety Status of Operating Plants

AERB carried out safety review and monitoring of operating NPPs and Research Reactors. The Safety Review Committee for Operating Plants (SARCOP), the apex committee for safety review of operating plants, held 17 meetings during the financial year 2010-11. The Unit Safety Committees (USC) established under SARCOP met a number of times to review safety related issues of individual plants in detail. The number of meetings conducted by various safety committees during financial year 2010-11 is given in Table 2.3.

Table 2.3: Meetings of Safety Committees

Name of the Safety Committee	No. of Meetings
SARCOP	17
TAPS-1& 2 Safety Committee	11
TAPS- 3 &4 Safety Committee	10
RAPS-MAPS Safety Committee	10
NAPS-KAPS Safety Committee	19
KGS-1to 4 and RAPS-3 to 6 Safety Committee	16
IGCAR Safety Committee	5
SARCOP Standing Committee - Reactor Physics	16
SARCOP-Standing Committee on Control & Instrumentation	3
Expert Group on Coolant Channels	4

2.3.2 Consents/Clearances/Permissions Issued

During the year, a number of applications from the utilities were reviewed and several authorizations / clearances / permissions were issued. Important among them are:

1. Restart of NAPS-2 after en-masse coolant channel replacement (EMCCR) campaign

2. Restart of KAPS-1 after EMCCR campaign

3. Extension of the construction clearance for Additional Away From Reactor (AAFR) Spent Fuel Storage Facility at TAPS-1&2 upto June 30, 2011

4. Renewal of License for Operation of KAPS-1&2 upto July 31, 2014

5. Extension of permission for operation of MAPS-1&2 upto September 30, 2011

6. Extension of permission for operation of TAPS-1&2 upto June 30, 2011

2.3.3 Operating Plants Safety Review

Detailed review of the significant events / incidents that occurred in NPPs was carried out by respective safety committees and SARCOP. Important among these are:

1. An incident involving fall of Cobalt Self Power Neutron Detector (SPND), used for in-core flux monitoring, outside the shielding flask during its removal from TAPS-4 reactor core.

2. An incident involving loss of power supply to a safety related motor control centers (MCC) in MAPS-1 during reactor operation affecting the valves of one shutdown cooling loop and some valves of the redundant emergency core cooling system.

The safety status of individual NPPs and research reactors is described below:

(i) General

Revision of the Limits on Discharge of Radioactive Effluents from Nuclear Power Plants

The limits on disposal of radioactive waste from NPPs are prescribed in the Authorisation for Safe Disposal / Transfer of Radioactive Waste, issued under Atomic Energy (Safe Disposal of Radioactive Wastes) Rules 1987 (GSR-125) and also in the technical specifications for operation of these stations. The limits prescribed in the

authorisation for safe disposal / transfer of radioactive waste are based on the operating experience of the facility and consideration of As Low As Reasonably Achievable (ALARA) practices for optimizing the waste disposal. These authorisations are valid for three years, after which these are renewed based on the request from the facility. The technical specifications limits are derived based on the dose apportionment and dispersion of effluents in the environment. These values generally originate from the preliminary safety analysis reports. In older NPPs, these limits were derived at the inception stage and have remained unchanged. Prior to the year 2010, the authorised limits on release of radioactive effluents from NPPs were significantly lower than the corresponding technical specifications limits for most cases. With effect from January 2010, these limits were rationalized and same limits were prescribed for discharge of radioactive effluents in the authorisation for safe disposal / transfer of radioactive effluents and in the technical specifications of NPPs. The new limits considered the dilution effects in the aquatic bodies also. To the extent possible, similar limits have been prescribed on discharge of effluents from plants of similar designs. In addition, the limits of radioactive discharges from RAPS-1&2 were prescribed considering operation of single units only. Application of this approach resulted in downward revision of the earlier technical specifications limits in most of the cases.

Increase in Operating Power of NPPs

Most of the PHWR NPPs in India have been operating at reduced power levels since 2004 due to mismatch in fuel demand and supply. This led to operation of the reactors in a peak neutron flux mode, wherein the power produced in the central region of the core is higher than that in the outer region. This mode of operation was resorted for optimal use of the natural uranium fuel available in the country. Consequent to placing the units at RAPS-3&4 and KAPS-1&2 under the IAEA safe guards and easing of the fuel supply for these stations, NPCIL has proposed to increase the operating power in these units to 100 % FP. The proposed scheme involved raising the operating power of these units in steps by refueling the outer most channels in the reactor core. The scheme also involved restoration of flattened neutron flux in the reactor core, as envisaged in the original design of these reactors. The safety aspects of proposal for restoration of neutron flux pattern and increase in reactor power to the rated level were reviewed in detail by the Standing Committee on Reactor Physics and SARCOP. Based on the satisfactory review, SARCOP accepted the proposal. Presently, these units are operating satisfactorily upto 100 % FP.

(ii) TAPS-1&2 and TAPS-3&4

TAPS-1&2 and TAPS-3&4 operated safely during the year.

Extension of the Construction Clearance for Additional Away From Reactor (AAFR) Spent Fuel Storage Facility at TAPS-1&2

TAPS site has an Away From Reactor (AFR) spent fuel storage facility for storing spent fuel discharged from TAPS–1&2 reactors. This facility was constructed in the year 1990 and was designed for storage of 2000 spent fuel bundles discharged from TAPS. AFR is close to its full capacity. In order to provide additional storage space for spent fuel that would be generated during future operation of TAPS-1&2 reactors, NPCIL has undertaken construction of an Additional AFR (AAFR) facility adjacent to the existing AFR. In June 2009, AERB had granted clearance for construction of AAFR, Tarapur. Based on the schedule for construction of this facility, clearance was issued with validity upto December 31, 2010. Subsequently, NPCIL informed that there was a delay in construction of the facility due to various reasons. Considering this delay, NPCIL requested the extension of the construction clearance of this facility upto the end of June 2011, before which the facility is expected to be put into service. Based on the request of NPCIL and the schedule of construction of the facility, the validity of construction clearance of AAFR, TAPS-1&2 was extended upto June 30, 2011.

License for Operation of TAPS-1&2

The license for operation of TAPS-1&2 was valid till March 31, 2011. TAPS submitted an application requesting renewal of license for operation of these units for the next five years. The application was reviewed in detail in AERB. The review, covered aspects related to operational performance, significant events, radiological safety performance, status of safety related systems & equipment and environmental discharges. These reviews indicated that the operational safety performance of TAPS-1&2 has been satisfactory during the reporting period. These units have been in operation for more than 40 years. Performance of various systems and components has been reported to be satisfactory. The in-service inspections carried out so far have not revealed any significant degradation. However, there are some pending issues, which include monitoring the healthiness of inaccessible welds of the reactor vessel, containment inerting, boat sampling of core shroud etc. need to be resolved. Moreover, in wake of the accident at Fukushima NPPs in Japan, it has now become necessary to review the safety margins of TAPS-1&2 against severe natural events, flood and earthquake in particular, and the consequent multiple failures. Pending the resolution of these issues, the permission for continuing operation of TAPS-1&2 was granted for a limited period of three months, i.e. upto June 30, 2011, to facilitate TAPS-1&2 / NPCIL to carry out necessary reviews for resolution of the issues.

Incident of Cobalt SPND Falling Outside the Shielding Flask in Pump in TAPS -4

Self powered neutron detectors (SPNDs) are used for in-core neutron flux measurements in TAPS - 3 & 4. SPNDs made of cobalt are used for reactor protection system and reactor regulation system whereas vanadium SPNDs are used for flux mapping system. These SPNDs have finite life span over which they lose their sensitivity and need to be replaced with fresh one. Being in the reactor environment, these SPNDs and cable connections (mineral insulated) to them becomes highly radioactive. The process of removal of SPNDs involves retrieval of SPND along with the connected cables into a shielded flask remotely. On July 7, 2010, during replacement of one of the cobalt SPNDs from TAPS-4, its cable got disconnected and the SPND fell outside the shielding flask. This resulted in significant increase of radiation levels in nearby areas within the reactor building. TAPS-3&4 and NPCIL worked out a detailed action plan for retrieval of the SPND. Personnel involved in the retrieval operation were trained on the mockup facility. AERB conducted a special regulatory inspection to assess the situation at site and the preparedness of station for retrieval of the SPND. On July 16, 2010, this SPND was retrieved into the shielding flask using the special procedure. The whole operation was carried out from behind a lead shield plate. There was no case of overexposure during the process of retrieval of the fallen SPND. During review of the event, SARCOP has asked TAPS-3&4 and NPCIL to revise the procedure for removal of SPND to avoid occurrence of such events in future.

(iii) RAPS - 1 to 4

RAPS- 1 continues to be under shutdown with all the fuel bundles removed from the reactor core. RAPS-units 2, 3 & 4 operated safely during the year.

(iv) MAPS-1&2

Both the units operated safely during the year.

License for Operation of MAPS

The license for operation of MAPS-1&2 was valid till December 31, 2010. MAPS submitted an application requesting authorization for operation beyond December 31, 2010. This application was reviewed in detail by AERB. These reviews covered the aspects related to operational performance, significant events, radiological safety performance, status of safety related systems & equipment and environmental discharges. NPCIL has carried out seismic re-evaluation of MAPS. Based on the findings during this re-evaluation, supports of some of the equipment / structures had been strengthened. Detailed review of the reports on seismic re-evaluation of MAPS was carried out by an expert committee constituted by SARCOP. This review indicated that the systems, structures and components (SSCs) required to carry out the functions of safe shutdown, long term decay heat removal and containment of radioactivity are capable to perform the intended functions during site specific ground motion. Reviews related to renewal of license for operation of MAPS indicated that performance during the previous authorization period and safety status of the units was satisfactory. However, in wake of the accident at Fukushima NPPs in Japan, it has now become necessary to review the safety margins of MAPS-1&2 against severe natural events and multiple failures. Pending the resolution of these issues, permission for continuing operation of MAPS-1&2 was granted for a limited period of six months, i.e. upto September 30, 2011, to facilitate MAPS-1&2 / NPCIL to carry out necessary reviews and resolution of the issues.

Incident of Loss of Power Supply to a Safety related MCC in MAPS-1 during Reactor Operation

There was a significant event in MAPS-1 in April 2010, which resulted in unavailability of power supply to one safety related electrical power supply MCC during reactor operation. Earlier, a similar incident had occurred in the station during April 2009. The affected bus is required to remain charged during reactor operation. The loss of power supply to this bus resulted in unavailability of the valves of one of the shutdown cooling circuit and some of the redundant valves of emergency core cooling system. These systems are not required during normal operation. However, the effect on these systems due to failure of MCC involved deviation from technical specifications requirements. The cause of loss of power supply to the affected bus was attributed to the absence of earth fault protection on one of the circuit breakers connected to this MCC. The affected MCC was restored immediately. RAPS-MAPS Safety Committee and SARCOP reviewed this event in detail. To avoid recurrence of such event, MAPS has provided necessary earth fault protection on the circuit breakers in unit - 2, which would quickly isolate the earth fault and prevent loss of power supply to the MCC. A similar scheme will also be implemented in unit -1 during forthcoming shutdown in June 2011.

(v) NAPS-1&2

NAPS-1 operated safely during the year. NAPS-2 was under shutdown for EMCCR and upgradation activities since December 18, 2007. After completion of these activities, the unit was subsequently synchronized to grid on September 6, 2010. The unit has operated satisfactorily since then.

Restart of NAPS-2 and KAPS-1 after EMCCR Campaign

NAPS-2 and KAPS-1 were under shutdown since December 18, 2007 and July 1, 2008 respectively for EMCCR and other upgradation jobs. During this outage, the old Zircaloy -2 pressure tubes were replaced by coolant channels having Zirconium Niobium pressure tubes with four tight fit garter springs. The new coolant channels are expected to have longer life span as compared to the Zircaloy- 2 channels, owing to lower hydrogen pick up during reactor operation and reduced possibility of movement of garter spring spacers from their design locations. Taking advantage of this long shutdown, all feeder pipes of the PHT system were also replaced with feeder pipes having higher resistance to flow assisted corrosion. A number of upgradation jobs were also carried out which will help in enhancing the safety and availability of these units. Inspection of a number of plant systems and components was carried out to monitor their condition. During the EMCCR outage, KAPS also completed jobs related to identification and repair of the seepage of light water from calandria vault in unit-1, a problem which was existing since March 1998. Activities related to EMCCR, feeder replacement, system upgradation and results of inspection of plant systems were closely reviewed and monitored by a special sub-committee constituted by SARCOP and the NAPS-KAPS Safety Committee. After completion of these activities, NAPS and KAPS submitted applications for restarting of the respective units. These applications were reviewed in detail by OPSD and the safety committees under SARCOP. Special regulatory inspections were conducted to check the status of completeness of the jobs and preparedness for restart of these units. Based on the satisfactory review of the applications and observations made during regulatory inspections, AERB accorded permission for restart of these units. NAPS-2 was made critical on August 29, 2010 and subsequently synchronized to the grid on September 6, 2010. KAPS-1 was made critical on December 31, 2010 and synchronized to the grid on January 12, 2011. Performance of both these units is satisfactory since their restart after the EMCCR outage.

(vi) KAPS-1&2

KAPS-2 operated safely during the year. KAPS-1 was under shutdown for EMCCR since July 1, 2008. The unit was made critical on December 31, 2010 after successful completion of EMCCR activities and has operated safely since then.

Renewal of License for Operation of KAPS-1&2

The license for operation of KAPS-1&2 was valid till July 31, 2009. In June 2009, KAPS had submitted an application for renewal of license for operation of KAPS unit-1&2 for the period from August 1, 2009 to July 31, 2014. The application was reviewed in detail in AERB. These reviews indicated that though the safety performance of the units was satisfactory, actions to address some of the issues such as revision of technical specifications for operation, modifications for facilitating online surveillance testing of reactor protection system logics, etc were in progress. Also KAPS-1 was in long outage for EMCCR activities. In view of this, the license for operation of KAPS-1&2 was extended upto the end of December 2010. The issues related to KAPS-1 were satisfactorily addressed by systems upgradation during EMCCR outage of the unit. Considering this, the license for operation of KAPS-1&2 was extended upto July 31, 2014.

(vii) KGS-1& 2 and KGS-3

KGS-1, 2 & 3 operated safely during the year.

Primary Containment Integrated Leakage Rate Test (PCILRT) at KGS-2 at Higher Pressure

Reactor building containment of PHWRs based NPPs is designed to house the reactor, steam generators and auxiliary systems. The major function of containment system is to limit the radioactivity releases to the environment from reactor core and from reactor coolant system during and after accident conditions. Usually there are minor leakages from the containment through the micro pores of concrete and the construction joints. The pre-operational PCILRT is conducted at the peak pressure corresponding to the postulated design basis accident. Periodically, PCILRT is carried out to demonstrate that leakage from the containment satisfies the acceptance criteria specified in the technical specifications. Presently, PCILRT of PHWRs of NPCIL is conducted at a frequency of once in two years, as per the technical specifications requirements. This test is conducted at a reduced pressure, typically one third of the peak pressure expected following postulated design basis accident. AERB Safety Guide on 'Proof and Leakage Rate Testing of Reactor Containments (AERB/SG/O-15)' specifies more elaborate tests for the containments, which include PCILRT at pre-operational test pressure initially at 4 years after the first criticality and subsequently once in 8 years. AERB had earlier advised NPCIL to review the feasibility of complying with the tests specified in the AERB Guide. Subsequently, NPCIL came out with a proposal for carrying out one time ILRT at full LOCA pressure in KGS-2 on trial basis, to assess the usefulness and to identify any operational problems in conducting such test. Accordingly, PCILRT of KGS-2 was carried out at a higher pressure. The test was witnessed by the representatives of AERB also. The response of the containment and other systems was satisfactory and there were no major operational problems during the test. This

test has demonstrated that reactor building primary containments can be tested satisfactorily at higher pressure. In the light of the test at KGS-2, conducting regular PCILRTs of PHWRs at high pressure is being considered.

(viii) Indira Gandhi Center for Atomic Research

Fast Breeder Test Reactor (FBTR)

The 16th irradiation campaign of FBTR was started on February 11, 2010 to conduct the following experiments:

- Irradiation of PFBR test fuel sub-assembly
- Irradiation of structural materials
- Testing of PFBR in-core detectors
- Measurement of fuel sub-assembly bowing

Peak reactor power during this campaign was 18 MWt. The initial target burn-up of PFBR test sub-assembly (100 GWd/t) was revised to 112 GWd/t after approval of SARCOP. The 16th irradiation campaign of FBTR completed after the PFBR test fuel sub-assembly reached this burn-up value. FBTR submitted a proposal for 17th irradiation campaign to continue other experiments. It was proposed to remove the PFBR test fuel sub-assembly and load another two fuel sub-assemblies in the core. The target power for the 17th irradiation campaign is about 22.5 MWt. While considering the proposal, performance of various systems during the 16th campaign and the effects of increase in reactor power on fuel sub-assemblies were reviewed in detail. Considering all the safety aspects, AERB agreed to the proposal for 17th irradiation campaign of FBTR.

Reprocessing of FBTR Spent Fuel Sub-assembly at CORAL, IGCAR

Fast reactor fuel reprocessing, being a complex technology, is being implemented in stages. These include testing of equipment and systems in the engineering laboratories and then integrating them in a hot cell for radioactive runs. FBTR fuel reprocessing is being carried out in the CORAL facility (earlier called LMC), set up in Reprocessing Development Laboratory of IGCAR. IGCAR had successfully completed fourteen campaigns of reprocessing of FBTR fuel pins in this facility, which included the two campaigns of reprocessing of 20 fuel pins each irradiated upto a burn-up of 155 GWd/t. Considering this, IGCAR requested for authorization for regular reprocessing of FBTR fuel irradiated upto 155 GWd/t. The review of this proposal brought out some improvements which need to be implemented at the facility before according permission for regular reprocessing at the facility. These were related to augmentation of boron coated counter (BCC) system, upgradation of power supplies, higher than normal radiation fields in the continuously occupied areas such as control room & active analytical laboratory (AAL), stricter implementation of bio-assay programme, etc. Pending implementation of these improvements, IGCAR requested permission for reprocessing of one FBTR fuel sub-assembly, having fuel pins irradiated upto 155 GWd/t. SARCOP constituted a specialist committee, for investigation of higher than expected radiation fields in the continuously occupied plant areas and to reduce collective dose at the facility. After a detailed review, the specialist committee made a number of recommendations for reducing radiation fields in the CORAL areas. After implementation of these recommendations by IGCAR, permission was given for reprocessing of one FBTR sub-assembly, having fuel pins irradiated up to 155 Gwd/t.

KAMINI

KAMINI reactor remained operational for conducting various irradiation and neutron radiography experiments.

(ix) RAPPCOF

RAPPCOF has recently undertaken fabrication of indigenous cobalt teletherapy sources (CTS). This involves handling of active cobalt radiation sources inside the hot-cell. This operation is performed remotely from outside the hot cell. So far, seven numbers of CTS have been fabricated at RAPPCOF. During the process of fabrication of these sources, spread of contamination was observed inside the hot-cell. The further fabrication of CTS was stopped and decontamination of hot cell was undertaken. During the period of decontamination of hot cell, spread of contamination was observed in the other areas of facility, which are normally expected to be free of contamination. Immediately all these locations were cleaned up and actions were taken to prevent spread of contamination. RAPPCOF has informed that no contamination was observed at these locations subsequently. A special regulatory inspection was conducted by AERB to assess the situation at the facility. The inspection team observed certain weaknesses in radiation protection practices at the facility. The incident has been reviewed in detail in RAPS-MAPS Safety Committee. The review indicated a need for the detailed review of the procedures for fabrication of CTS. Considering this, RAPPCOF has been asked to suspend fabrication of CTS at the facility. The resumption of CTS fabrication in the facility will be subject to a detailed review by RAPS-MAPS Safety Committee / SARCOP.

2.3.4 Regulatory Inspections

During the period from April 2010 to March 2011, a total of 31 inspections were undertaken in the operating NPPs and research facilities, out of which 24 were scheduled inspections and 7 were special inspections.

Special regulatory inspections were conducted to check the preparedness for restart of NAPS-2 and KAPS-1 after EMCCR campaign. A special inspection of TAPS-3&4 was conducted subsequent to an incident of Cobalt SPND falling outside the shielding flask in pump room of TAPS -4 to assess the situation at site and the preparedness of station for retrieval of SPND. A special inspection of RAPPCOF was undertaken after the spread of contamination in the facility. Another special inspection was conducted at TAPS-1&2 to assess the capability of plant against the natural calamities like flood, earthquake and tsunami. Other special inspections were carried out to observe the activities during containment test at KAPS-2 and KGS-2.

The observations during the scheduled regulatory inspections are broadly categorized as follows:

Category: I	Deviations from technical specifications and other regulatory requirements/ stipulations.
Category: II	Deficiencies and degradations in systems/ structures/components of safety and safety related systems and deficiencies in important procedures to meet the technical specifications & reporting criteria
Category: III	Shortcomings identified in the design of safety, safety related and safety support systems, based on operating experience including generic deficiencies.
Category: IV	Procedural inadequacies.
Category: V	Observations on housekeeping and departure from good practices.

Category wise distribution of observations in different plants during the period April 2010 to March 2011 are given in Tables 2.4.

Table 2.4 : Categorization of Deficiencies Observed during Scheduled Regulatory Inspections (April 2010 to March 2011)

Unit	Number of Inspections		Cat. I	Cat. II	Cat. III	Cat. IV	Cat. V	Total
	Planned	Special						
TAPS-1&2	2	1	3	3	9	42	11	68
TAPS-3&4	2	1	0	1	8	50	1	60
RAPS-1&2	2	0	0	3	6	63	5	77
RAPS-3&4	2	0	1	0	1	41	25	68
MAPS-1&2	2	0	0	5	4	44	5	58
NAPS-1&2	2	1	2	3	4	49	0	58
KAPS-1&2	2	2	0	1	3	68	0	72
KGS-1&2	2	1	0	2	8	44	6	60
KGS-3&4	2	0	0	3	6	42	8	59
RAPPCOF	1	1	0	0	0	0	0	0
FBTR & KAMINI	1	0	0	6	4	27	1	38
Radio Chemistry Lab	1	0	0	0	0	0	0	0
Radio Metallurgy	1	0	0	0	0	0	0	0
LEAD MINI CELL A,B,C	1	0	0	2	7	11	2	22
FRTG NO	1	0	0	0	0	0	0	0
Total	24	7	6	29	60	481	64	640

Some of the salient observations made during the above regulatory inspections are as follows:

1. Configuration of ALPAS of RAPS-3&4

Adjuster rods and ALPAS are used for the regulation of reactor power in RAPS-3&4. It was observed that ALPAS line joins the moderator system at upstream of the moderator purification return line isolating valve. This valve is normally kept open during reactor operation. However, if this valve gets closed, either manually or automatically, ALPAS will not be available to inject poison into the moderator system. Station was asked to make suitable changes in system configuration so as to ensure that availability of reactor regulation through ALPAS is not affected by the position of the isolating valve of the moderator purification system.

2. Surveillance of Dedicated Instrument Air Supply to Important Valves of RAPS-2

Dedicated instrument air accumulators have been provided for the pneumatic valves of emergency core cooling system (ECCS) and steam dump valves (SDV) of RAPS-2 to ensure operability of these valves in the event of instrument air supply failure. In RAPS-2, it was observed that the pressure decay test of these accumulators and associated piping was not done. Station was asked to formulate a surveillance program to ensure ability of the system to do its required functions in case of loss of instrument air supply.

3. Surveillance of Fuelling Machine Vault Coolers at KAPS-1&2

Air coolers have been provided in the fuelling machine (FM) vaults of KAPS-1&2 to automatically cool and depressurize the reactor building environment (by condensing of steam) in the event of loss of coolant accident (LOCA). At KAPS-1&2, it was observed that the operability of FM vault coolers was checked during routine tests. However, the auto start logics of the fans of these coolers were not tested. Station was asked to institute a surveillance programme for testing of these logics.

4. Power Supply Arrangement for the Fans of Primary Containment Filtration and Pump Back System of NAPS-2

Primary containment filtration and pump back system (PCFPBS) is provided at NAPS-1&2 to filter out the airborne contaminants in the reactor building during loss of coolant accident. This system has two fans of 100% capacity each. It was observed that the power supply for both the fans of PCFPBS of NAPS-2 was taken from the same electrical power supply bus. This was not in line with the design philosophy of electrical systems as the unavailability of this bus could result in unavailability of both the fans of PCFPBS. Station was asked to segregate the power supply for the fans of PCFPBS.

5. Surveillance Check on Control Valve in Back-up Heavy Water Line to Fueling Machine of RAPS-3&4

At RAPS-3&4, refueling is done on-power in various coolant channels, wherein fresh fuel bundles are loaded from one end of the reactor core with a fuelling machine. The spent fuel bundles are discharged from the other end with other side fueling machine. Normally, a fueling machine pump supplies heavy water to these machines during refueling operation, which ensures that the hot water from the reactor channel does not come into the fueling machine. There is a standby fueling machine pump also. However, for the low probability event involving unavailability of both the fueling machines pumps during refueling operation, a provision exists for automatically supplying heavy water to the fueling machines from primary pressurizing pumps. This back-up water supply to fueling machine is through a flow control valve. During regulatory inspection, it was observed that there was no programme for periodic surveillance of this control valve. Station was asked to carry out surveillance of this control valve to ensure its availability. Accordingly station has included the testing of this control valve in surveillance schedule.

6. Testing of a new Logic of Reactor Trip at KGS-1&2

At KGS-1&2, four primary coolant pumps (PCPs) are provided in PHT system with two pumps each on north side and south side of the reactor core. A reactor trip on 'No primary coolant pump running on either bank' was recently introduced to trip the reactor in case of tripping of both the PCPs on one side. During the RI, it was observed that after implementation of this trip, testing of the logic was done through the online test facility only and actual functional test from field was not carried out. Station was asked to carry out the testing from field also. Subsequently, station has carried out testing of this logic from field also. In addition, this test has been included in regular surveillance programme.

7. Surveillance of SSS Trip on Moderator Level High at KGS-1&2X

At KGS-1&2, very high moderator level in calandria is an indication of loss of coolant accident involving rupture of coolant channel. Accordingly, a reactor trip on very high moderator level has been provided wherein both the reactor shutdown systems, viz.

primary shutdown system and secondary shutdown system, actuate to trip the reactor. During inspection, it was observed that the testing of actuation of secondary shutdown system on moderator level very high was done from the on-line trip test parameter facility. However, the functional test of this logic from the field was not done. Station was asked to carry out the functional test of this logic from the field also. Accordingly station has included this test in its surveillance programme.

8. Surveillance of the Logics of Diesel Generators at KGS-3

At KGS-3&4, the logic for operation of diesel generators is such that during the postulated event of loss of coolant from the core, only essential protections of diesel generators are kept in service, which include trip on differential protection, over-speed protection and fire protection. The other trip logics are by-passed to improve the availability of these diesel generators under accident conditions. During an inspection, it was found that the surveillance of the logic for bypassing of other trip parameters of diesel generators was not done. Station was asked to do the surveillance check of this logic. Following the recommendation, station has included the above logic test in DG maintenance procedure and the logic will be tested periodically.

9. Procedure for Surveillance of Emergency Transfer (EMTR) Relays at MAPS

An EMTR Scheme has been provided in the electrical power supply system of MAPS, which actuates during the loss of normal power supply and restores power to selected loads through diesel generators. The testing of this scheme from EMTR panel is done once in six months to check the operation of various relays. The test takes about one hour time. As per the test procedure, the operation of DGs was prevented during this test to avoid frequent starts during the test. Station was asked to modify the surveillance procedure to ensure the availability of diesel generators during this test. Based on the recommendation, station has revised the procedure and the DGs are kept available for start on auto during this test also.

2.3.5 Licensing of Operating Staff

The number of operating personnel, who were licensed from various NPPs during the year April 2010 to March 2011, is tabulated in Table 2.5. In addition, for the operation of FBTR, four persons were licensed / re-licensed for the position of junior shift engineer and six persons were licensed / re-licensed for the position of control room assistant / field supervisor. Two persons were licensed for the position of senior shift engineer and one person was licensed for the position of senior fuel handling engineer in FBTR. For the operation of KAMINI, two persons were licensed for the position of senior shift In-charge.

Table 2.5: Licensing of Operating Staff (April 2010 to March 2011)

Plants	No. of Persons Licensed					Licensing Committee Meetings
	SCE	ASCE	ASCE(F)	CE	CE (F)	
TAPS-1 & 2	8	1	-	2	-	2
TAPS-3 & 4	6	3	2	14	4	3
RAPS-1 & 2	3	1	2	9	1	2
RAPS-3 & 4	6	4	3	10	3	2
RAPS-5 & 6	9	10	3	8	2	2
MAPS-1 & 2	2	1	1	9	6	2
NAPS-1 & 2	3	2	2	7	3	2
KAPS-1 & 2	3	4	1	7	1	2
KGS-1 & 2	3	3	4	6	0	2
KGS-3 & 4	3	2	0	10	4	2
Total	46	31	18	82	24	21

Management Positions: Ten persons have been re-qualified for the management positions at various NPPs.

2.3.6 Significant Events

It is obligatory for operating NPPs to report promptly to regulatory body, certain events that occur in the plant which have or may have impact on operational safety. Under the reporting system established by AERB, the events reportable to the regulatory body are divided into two categories, termed as,

(a) Events and
(b) Significant Events.

This categorization depends on the safety significance and importance to operational safety experience feedback. Based on the reporting criteria, event reports (ER) and significant event reports (SER) are submitted to AERB.

The SERs received from the operating NPPs are also rated on the INES. The INES system of IAEA, rates the events at seven levels (1 to 7) depending on their safety significance. Events rated at level 4 and above are termed as accidents. The accident at Chernobyl nuclear power plant in former USSR (now in Ukraine) and the accident at Fukushima Daiichi NPPs were rated at level 7 on INES. These accidents involved core melt down with the consequences of large-scale off-site radioactivity release having wide spread environmental and human health effects. Events rated at levels 1, 2 and 3 are called incidents. Events with no safety significance are rated at level 0 or below scale. The IAEA-INES scale is depicted at the end of the report.

In the year 2010, a total of 34 significant events were reported from the operating NPPs. The system wise classification of SERs in NPPs is given in Fig. 2.1. The classification of SERs on INES scale is given in Fig. 2.2. The number of SERs in NPPs during the last five years and their ratings on INES scale are given in Table 2.6.

One significant event of the year 2010 was rated at level 1 on INES as this had resulted in exposure of 16.42 mSv to a temporary worker, which is beyond the annual radiation exposure limit of 15 mSv specified by AERB. This worker was involved in the calandria vault repair job which was carried out during EMCCR outage of KAPS-1. The other 33 significant events were rated at level 0 on INES. Out of these, six events (three at RAPS-2 and one each at MAPS-1, KAPS-1 & RAPS-3&4) that involved deviation from technical specifications requirements are briefly described below.

At RAPS-2, there were three occasions when MCCs / circuit breaker supplying power to safety equipment had been taken out of service during reactor operation to meet their preventive maintenance schedule. This resulted in unavailability of shutdown cooling pump or emergency boiler feed pump during the period of preventive maintenance and thus led to instances of deviation from technical specification requirements.

In an another event at RAPS-2, the integrity of one barrier between V1 and V2 areas (low & high enthalpy areas) of containment was not available for about 7 hours due to non-closure (5% open) of the mini-shielding door of north fuelling machine vault. The door could not be fully closed due to loosening of the mounting brackets of door's hydraulic actuator.

In an event at MAPS-1, absence of earth fault protection on fuelling machine pump breaker resulted in opening of incoming circuit breaker of Class-II bus. As a result of loss of potential to Class-II bus, power supply to one of the two shutdown cooling loop valves and some valves of the redundant ECCS was lost for about 20 minutes while reactor was in operation. The affected bus was charged immediately after isolation of the fault. Earlier also, a similar incident had occurred in the station during April 2009. To avoid recurrence of such event, MAPS has provided earth fault protection on the breakers of fueling machine pump motors in unit - 2, which will quickly isolate the fault and prevent loss of Class-II power supply. A similar scheme will be implemented in MAPS-1 during forthcoming BSD, which is planned in June 2011.

During 25 ton heavy water addition to calandria in KAPS-1 after EMCCR, moderator and its cover gas system showed deterioration in chemistry parameters (e.g. pH, conductivity, Oxygen, Nitrogen etc.) beyond the normal range values specified in station technical specifications. Co-60 activity in the moderator was observed to be increased to 700 μCi/l the normal value of less than 1 μCi/l. The general radiation fields in moderator room increased to 600 mR/h from 50-60 mR/h. On observing this, moderator purification system was taken in service and the system chemistry was brought back to normal. Prior to this, heavy water from the moderator system was drained and the system was kept empty in dry condition during the EMCCR outage by filling with instrument air. Incomplete draining of moderator system during the EMCCR outage and inadequate purging of the system with helium prior to taking it back into service were assigned as the probable reasons for deterioration in the moderator chemistry.

At RAPS-3&4, one deficient environmental radiation monitors (out of six) was left unattended for about 3 months as the identified deficiency was tried to be addressed through informal means rather following the work permit system.

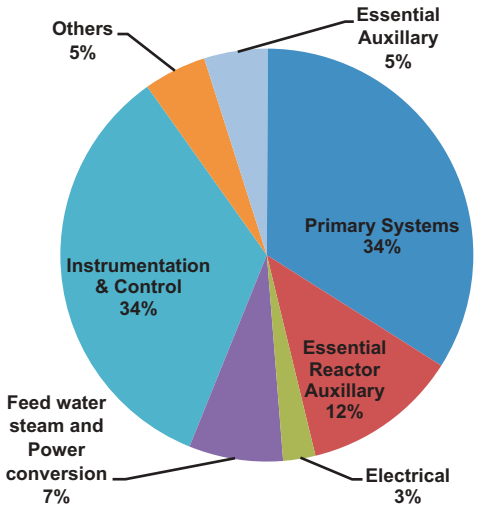


Fig. 2.1: System wise classification of SERs in NPPs during the year 2010

Table 2.6: Classification of SERs in NPPs as rated on INES for last five years

INES Levels	2006	2007	2008	2009	2010
0	34	28	22	23	33
1	5	8	2	0	1
2	0	0	0	0	0
3	0	0	0	0	0
>3	0	0	0	0	0
Total	39	36	24	23	34

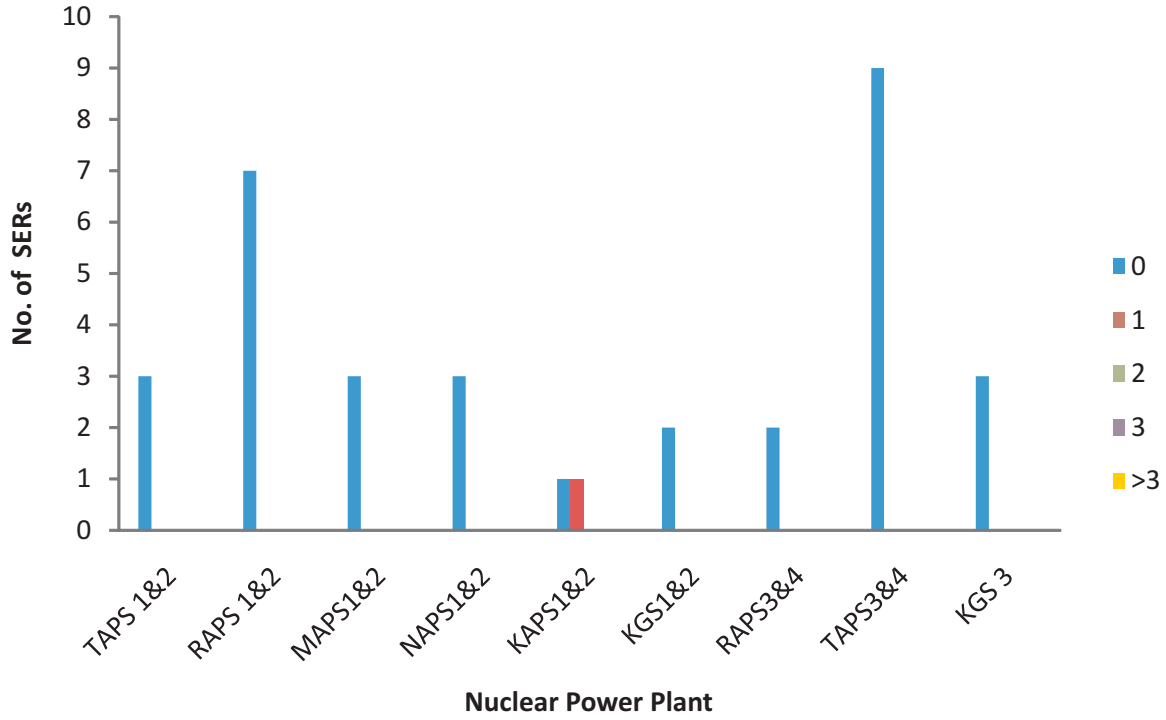


Fig. 2.2: INES ratings of SERs in NPPs (Year 2010)

2.4 FUEL CYCLE FACILITIES

The nuclear fuel cycle facilities under regulatory control are Uranium Corporation of India Ltd. (UCIL) mines and mills, Indian Rare Earths Limited (IREL) plants, Nuclear Fuel Complex (NFC), Heavy Water Plants (HWP), Atomic Minerals Directorate for Exploration and Research (AMD) and Fast Reactor Fuel Cycle Facility (FRFCF). In addition, Beach Sand Minerals (BSM) and Naturally Occurring Radioactive Materials (NORM) facilities are also regulated by AERB.

A three-tier review process is followed for granting consent for major stages for large nuclear fuel cycle facilities. The first level of review is by Design Safety Review Committee (DSRC) or respective Unit Safety Committee (USC) of the facility followed by second level of review conducted by Advisory Committee for Project

Safety Review- Fuel Cycle Facilities (ACPSR-FCF) and the third and final review is by the regulatory body/Board. For other facilities, a two-tier review process is followed with first level of review conducted by DSRC or respective USC of the operating facility and second level of review by ACPSR-FCF or SARCOP. Safety review of the operating plants is carried out by USC and SARCOP.

Highlights on safety status and reviews, regulatory inspections and licensing of personnel carried out with respect to the above facilities are given below.

2.4.1 Operating Plants/Project Safety Review

Safety review and monitoring of operating fuel cycle facilities was carried out. A number of applications related to issue/ renewal of licenses of these operating units were received in AERB. After detailed review of the applications and based on the satisfactory performance of the units, licenses were issue/renewed for operation of the units.

The status of safety review of various applications from operating fuel cycle facilities and important observations and recommendations made during the review are given below.

(i) Uranium Corporation of India Limited (UCIL)

The mines at Jaduguda, Bhatin, Narwapahar, Turamdih, Banduhurang, Bagjata and Jaduguda and Turamdih mills operated safely during the year.

Development work was in progress at Mohuldih, Tummalapalle and exploratory mining at Gogi. USC, SARCOP, DSRC-UEP and ACPSR-FCF reviewed the following proposals of the UCIL mines/mills for granting clearances.

- The application for renewal of license for operation of Jaduguda mill was reviewed in USC. In view of the transition of process changeover from Magnesium Di-Uranate to peroxide system at Jaduguda mill, the Safety Committee recommended for renewal of licence of Jaduguda mill for processing of 2090 MT of uranium bearing ore/day and production of Magnesium Di-Uranate / Peroxide product of Uranium with certain stipulations. It was further deliberated in SARCOP and license for operation of Jaduguda mill was renewed by AERB for a period of five years.

- Expansion of Banduhurang & Turamdih Mines was reviewed in USC and SARCOP and SARCOP approved the same with certain stipulations.

- Issue of personal radiation dosimeter (PRD) coverage for all mine workers.

- Proposal for safe disposal/transfer of radioactive wastes from Turamdih Mine.

- Safety report and design basis report related to buildings, structures of mill, tailings pond and dam for Tummallapalle and Gogi uranium ore processing project were reviewed.

(ii) Indian Rare Earths Limited (IREL)

The IREL plants at Chavara, Manavalakurichi, Chatrapur and Udyogamandal operated safely. Beach Sand Minerals Safety Committee (BSMSC), SARCOP and DSRC-UEP reviewed the industrial and fire safety and radiological safety status of the following proposals of the IREL plants.

- IREL plant operations of material processing plant (MPP) of IREL Udyogamandal were suspended from May 15, 2010 due to non-adherence to the stipulations of SARCOP. A proposal for permitting operation of MPP in a relocated area (in grid 1-5 of MPP) was reviewed and permission to resume operations in the relocated MPP was granted.

- Slurring, neutralization and pumping procedure of thorium oxalate at IREL, Udyogamanadal was reviewed.

- Proposal with respect to the opening of Silo 6 at IREL Udyogamandal was reviewed and the safety committee recommended that the utility should proceed with the opening of Silo 6 and adhere to the existing safety measures.

- Status of storage of thorium oxalate and disposal of solid wastes at IREL OSCOM was reviewed.

- Annual health physics reports of IREL plants were reviewed.

- Safety assessment report regarding the proposal for construction of 10,000 tpa monazite processing plant (MoPP) retrofitting with 15 tpa thorium nitrate plant at IREL, OSCOM was reviewed.

(iii) Nuclear Fuel Complex (NFC)

All the plants of NFC, Hyderabad operated safely during the year. After ensuring satisfactory compliance to the safety requirements, approvals for following proposals were recommended by NFC Safety Committee.

- The siting and construction for Niobium Thermit Production Facility, NFC, Hyderabad.

- Application for grant of operation clearance of zirconium complex (ZC), Pazhayakayal.

- Extension of authorisation for commissioning of 'Oxide production Facility & Sponge Production Facility' of ZC, Pazhayakayal upto April 31, 2011.

The above proposals are under further review by ACPSR-FCF.

(iv) Heavy Water Plants (HWPs)

HWPs at Thal, Baroda, Hazira, Kota, Manuguru and solvent facilities at Talcher operated safely. HWP-Tuticorin that remained under shutdown due to non-availability of synthesis gas from M/s Southern Petrochemical Industries Corporation (SPIC), has applied for 'Renewal of License for Operation of the Plant'.

The following important proposals/ safety issues were reviewed in the Heavy Water Plants Safety Committee (HWPSC) and SARCOP. After ensuring satisfactory compliance to the safety requirements, the following clearances /renewal of licenses were granted/given.

- The applications for renewal of license for operation of HWP-Manuguru, HWP-Kota and Talcher were reviewed in the HWPSC. It was further deliberated in SARCOP and based on the recommendation of SARCOP, the license for operation of the above units was renewed by AERB for a period of five years with certain stipulations.

- Installation of 'Hydrogen – Water Exchange Test Facility (Pilot Plant)' at HWP-Baroda was recommended by the safety committee with certain stipulations.

- Commissioning experience feedback of DCS with advanced PLC system at HWP-Kota was reviewed.

(v) Atomic Minerals Directorate for Exploration and Research (AMD)

Development of shaft is in progress at about 150 m below ground. Design Safety Review Committee for Uranium Extraction Projects (DSRC-UEP) carried out site visit in January, 2011 and reviewed the stipulations made in the authorization for mine development of Gogi mine.

(vi) FRFCF

FRFCF is planned for reprocessing of spent fuel of PFBR and AERB had issued siting consent for the same in Sept. 2006.

Safety review for granting the construction clearance is in progress. Seismic classification of SSCs and related aspects were discussed in detail and the designers have been asked to provide clarifications on the issues raised.

(vii) Beach Sand Minerals (BSM) & Naturally Occurring Radioactive Materials (NORM) Facilities

- Beach Sand Minerals Safety Committee (BSMSC) reviewed the radiological safety status and applications for issue of licenses for operation of the BSM plants which are as follows.

- Applications for license for operation of M/s V.V.Mineral at Yellapetta & Midalam, M/s Indian Ocean Garnet Sands Company Pvt Ltd., M/s Manickam Minerals, M/s Earth Mineral Resources Pvt Ltd. Unit I and M/s Earth Mineral Resources Pvt Ltd. Unit II at Tuticorin were reviewed in BSMSC and based on the approval from Chairman, SARCOP, licenses were issued for operation of above mentioned BSM facilities by AERB.

- The proposal of selling of tailings by M/s TGI Pvt. Ltd. to M/s V.V.Mineral, Yellapetta was reviewed and the safety committee approved the proposal.

- License application of M/s Sri Raghvendra was reviewed and committee asked the unit to resubmit the application giving details of quantity of monazite enriched tailings to be generated and the monazite content in the tailings.

- Siting and construction for setting up columbite tantalite processing plant at Himachal Pradesh by M/s CS Zircon is under review.

2.4.2 Consents/Clearances/Permissions Issued

The applications related to various new projects from various fuel cycle facilities for stage wise consent from AERB (i.e. siting, construction, commissioning, operation and de-commissioning) were reviewed in detail by DSRC/USC, ACPSR-FCF and regulatory body. The detailed safety assessment covered industrial, fire and radiological safety, waste management and environmental protection aspects of the projects and based on the above assessment following stage wise consents were issued.

- Siting of uranium ore processing plant and tailings management facilities of UCIL at Gogi, Karnataka.

- Construction of Tummalapalle mill and 'Tailings dam and pond' at Tummalapalle.
- Operation of Bagjata mine for ore processing capacity of 500 tpd.
- Operation of Turamdih mill for ore processing capacity of 3000 tpd.
- The validity of existing consent for commissioning of 'Technology Demonstration Plant (TDP)' of Heavy Water Board (HWB) at RCF, Chembur, Mumbai was extended by AERB up to the end of October 2011 with certain stipulations.

2.4.3 Regulatory Inspections

Regulatory inspections on industrial and fire safety aspects under the Atomic Energy (Factories) Rules – 1996, radiological safety aspects under the Atomic Energy (Radiation Protection) Rules, 2004 and waste management aspects under the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 were carried out. The major recommendations made were as follows:

(i) Fuel Cycle Facilities (FCF)

- At HWP-Hazira, the license under Rule 43 of Gas Cylinders Rules (2004) for filling breathing air set cylinders should be obtained.
- At HWP-Baroda, the modification procedure should be revised to incorporate HAZOP study and pre-start up safety review.
- At HWP-Manuguru, deficiencies in cooling tower louvers should be rectified and the structural stability of the cooling tower should be assessed on priority.
- At IREL, Udyogamanadal, fire call points should be installed in the relocated MPP and measures should be taken to comply with the annual whole body counting schedule.
- At ECIL, Hyderabad, periodic internal safety audit should be carried out in all divisions and records should be maintained.
- At HWP-Kota, appointment of certifying surgeon at HWP-Kota should be expedited.
- At IREL, Chavara, access control of active dump area should be implemented and enforced.
- At Turamdih Mill, UCIL, the effectiveness of dust extraction system at the cone crusher in the fine crushing area should be reviewed and actions taken to prevent spreading of dust.
- At NFC, Hyderabad, monitoring of negative pressure at the fume-extracting nozzle near mixers at Zirconium Oxide Plant should be carried out as per periodicity specified in the technical specifications for Zirconium Oxide Plant.
- At ZC, Pazhayakayal, the functional test of chlorine scrubber & emergency chlorine scrubber system should be done as per Technical Specifications surveillance requirements.
- At IREL, OSCOM, the ventilation of thorium oxide drying and packing room should be improved and collection system should be provided for floor wash in the thorium oxalate storage area.
- At UCIL, personal dosimeters should be issued to all mine workers and radium body burden measurement for all UCIL mines workers should be carried out periodically.

(ii) Beach Sand Minerals Facilities

Regulatory inspections were carried out at Non-DAE beach sand minerals facilities with respect to radiological safety aspects. The major recommendations arising out of regulatory inspections made were as follows:

- Collection bins for monazite enriched tailings should be prominently located at various locations in plant.
- Radiation monitoring at various locations of the plants should be carried out once in a month.
- The monazite-enriched tailings should be sold to companies having valid license from AERB under the Atomic Energy (Radiation Protection) Rules, 2004.
- The storage location for sub-graded mineral should be identified; barricaded and adequate care should be taken during transportation of the middling.
- Radiological dose estimation of the regular and contract workers should be carried out and records shall be maintained.
- Radiation caution boards should be displayed at all active areas in plant and storage yards.
- The storage areas for raw materials, finished products, enriched tailings and intermediate products should be identified and marked properly.

The observations during the scheduled regulatory inspections are broadly categorized as follows:

Category Type	Particulars
CATEGORY- I (CAT.I)	• Violation of Rules, Acts, AERB Codes & Standards, Tech. Specs. Requirements (Safety Limit, Limiting Safety System Settings and Limiting Conditions of Operation), SARCOP/AERB Safety Directives, Licensing conditions
CATEGORY- II (CAT.II)	• Deficiencies in Operating Systems and Safety Related systems • Deficiencies in Surveillance procedures/practices • Short comings identified in the design of Safety related equipment and working conditions based on plant's operating experience including Generic deficiencies. • Safety Review related observations.
CATEGORY-III (CAT.III)	• Procedural inadequacies in : ➢ Organizational, ➢ ISI, ➢ O&M procedures ➢ Training & Qualification, ➢ Radiation Protection Procedures, ➢ Radiological Waste management, ➢ Effluent management ➢ Emergency Preparedness
CATEGORY-IV (CAT.IV)	• General observations/deficiencies regarding ➢ House keeping and ➢ Good Operating/maintenance Practices

Category wise distribution of observations in different fuel cycle plants during the period April 2010 to March 2011 are given in Table 2.7.

Table 2.7 : Categorization of Deficiencies Observed During Scheduled Regulatory Inspections of Fuel Cycle Facilities (April 2010 to March 2011)

Unit	Number of Inspections		Cat. I	Cat. II	Cat. III	Cat. IV	Total
	Planned	Special					
UCIL	1	1	5	7	65	46	123
NFC	2	0	13	19	66	40	138
IREL OSCOM	2	0	2	22	43	10	77
IREL Udyogamandal	2	0	0	11	39	35	85
IREL Manavalakurichi	1	0	1	2	7	1	11
IREL Chavara	2	0	0	1	13	3	17
HWP-Manauguru	2	0	8	26	78	94	206
HWP-Kota	3	0	8	37	65	96	206
HWP-Talcher*	1	0	4	4	5	6	19
HWP-Tuticorin*	1	0	0	0	0	8	8
HWP-Thal	3	0	1	25	78	78	182
HWP-Baroda	3	0	2	21	95	86	204
HWP-Hazira	2	0	1	20	75	47	143
ECIL	2	0	6	11	24	52	93
RRCAT	2	0	6	59	29	18	112
VECC	2	0	8	18	78	26	130
Total	31	1	65	283	760	646	1754

Note *: The heavy water production at HWP-Tuticorin and Talcher remained suspended by Heavy Water Board.

Apart from the above, monthly and quarterly inspections of various construction sites of NPPs, Beach Sand Minerals manufacturing facilities and fuel cycle facilities were carried out.

2.4.4 Licensing of Plant Personnel

- Licensing committee for licensing of operating personnel for Heavy Water Plants met at HWP- Thal, Hazira, Baroda, Manuguru and Kota and authorised/re-authorised 63 operation personnel.

2.4.5 Significant Events

- On May 28, 2010, an incident of fall of a contract worker took place at new chlorination facility of Zirconium Sponge Plant, NFC. The victim, while trying to move to 7.6 m El, lost his balance and fell on concrete footing below the ground level. The person suffered head injury and multiple fractures in upper limb. This incident resulted into 31 man days loss.

- On September 23, 2010, an incident of leakage of Nitrogen Oxide (NOx) took place from the Crude Uranyl Nitrate Solution (CUNS) storage tank at New Uranium Oxide & Fabrication Plant – Oxide plant (NUOFP-O) of NFC during draining of the contents from the batch dissolution tank. The evolution of fumes was brought under control by adding water to cool the contents and by transferring the contents of the CUNS tank back the dissolver.

- On September 30, 2010, an incident of leakage of Nitrogen Oxide (NOx) took place during dissolution of sintered rejects at NUOFP-O, NFC. The incident took place due to excessive addition of nitric acid into the dissolver in view of suspected problem in the orifice plate.

These significant events were reviewed in detail by the respective safety committees and measures to prevent recurrence of such incidents, were recommended.

2.5 R&D UNITS AND OTHER FACILITIES

Safety review of Variable Energy Cyclotron Centre (VECC), Raja Ramanna Centre for Advanced Technology (RRCAT) and Electronics Corporation of India Ltd. (ECIL) were carried out.

A two- tier review process is followed, based on hazard level, for the above facilities with first level of review conducted by respective USC of the facility and second level of review by SARCOP.

2.5.1 Variable Energy Cyclotron Centre (VECC), Kolkata

The modernization activities of the existing cyclotron (K-130) has been completed and presently in operation. In Super Conducting Cyclotron (K-500), commissioning of the Radio Frequency (RF) system was under progress. In Radioactive Ion Beam Facility, phase wise testing of stable beam operation was in progress. In Medical Cyclotron Facility, construction work was under progress. The following proposal were reviewed by VECC-RRCAT Safety Committee (VRSC),

- Operational status of K-130 cyclotron at VECC, Kolkata.

- Status of seismic up-gradation of Super Conducting Cyclotron of VECC.

During regulatory inspection, AERB team recommended to carry out the Hazard and Operability (HAZOP) studies of the cryogenic system of Super Conducting Cyclotron, submit a detailed report on fire protection measures at VECC, conduct periodic testing of safety interlocks and prepare operating procedure for helium gas bag.

2.5.2 Raja Ramanna Centre for Advanced Technology (RRCAT), Indore

INDUS-I was operating and producing synchrotron 450 Mev beam energy at 100 mA current. Commissioning of INDUS-II at 2.5.Gev energy & 100 mA current is under progress. The 750 keV DC accelerator and 10 MeV Linear Accelerator (LINAC) is under operation. The commissioning of 10 MeV FEL Linac is in progress.

The following important proposals/ safety issues were reviewed in the VRSC and after ensuring satisfactory compliance to the safety requirements, the following clearances /renewal of licenses were granted.

- Regulatory clearance for commissioning of stages 3, 4 and 5 of 10 MeV FEL LINAC in INDUS-I building of RRCAT, Indore on April 1, 2010.

- Authorisation for operation of beamlines BL-8, BL-11 and BL-12 in INDUS-II.

During regulatory inspection and special inspection of RRCAT the significant recommendations made were: measurement of earth pit resistance of

building should be carried out periodically, disposal of arsine and phosphene gas cylinders should be initiated and proper shoring of excavated pits in ARPF facility should be ensured.

2.5.3 Electronics Corporation of India Limited (ECIL), Hyderabad

All the manufacturing units of ECIL are in operation except the Thermal Battery Division. Thermal Battery Division is under renovation. The commissioning tests of 10 MeV LINAC test facility is under progress.

The following important proposals/ safety issues were reviewed in the ECIL Safety Committee (ECILSC) and SARCOP and after ensuring satisfactory compliance to the safety requirements, the clearances /renewal of licenses were granted.

- The application for renewal of license for operation of ECIL was reviewed in detail by the ECILSC. The review focused mainly on industrial & fire safety and radiological aspects. Based on resolution of identified safety issues, license for operation of ECIL, Hyderabad was renewed by AERB for a period of five years.

- The proposal for setting up of 'Impact Test Lab' & 'Proof Assembly of MACE Telescope' were reviewed and the Safety Committee recommended for construction with certain stipulation.

- The proposal for setting up of electronics manufacturing facility at Tirupathi was reviewed and the committee accepted in principle and asked ECIL to submit the formal application with necessary information.

CHAPTER 3

RADIATION FACILITIES

3.1 INTRODUCTION

The radiation facilities in India are broadly classified as medical, industrial and research facilities. Medical facilities include diagnostic X-ray machines, telegamma units, medical Linear Accelerators (LINACs), brachytherapy units using manual and remote after loading techniques and nuclear medicine centres practicing diagnosis and therapy. Industrial installations include gamma and X-ray radiography equipment, gamma radiation processing plants, ionizing radiation gauging devices (nucleonic gauges) including well-logging devices and facilities manufacturing consumer products that contain radioactivity. Research installations include universities and other research institutes handling a variety of sealed and unsealed radiation sources and also X-ray facilities for research purposes.

Number of various radiation installations and radiation devices, which are regulated by AERB, are given in Table 3.1.

Table 3.1: Radiation Installations Regulated (January to December 2010)

Sr. No.	Type of Application	Number of Devices in use	Number of institutions
1	**Diagnostic X-ray**	~ 50,000	~ 40,000
2	**Computed Tomograhy**	~4000	~3000
3	**Radiotherapy**		306
	Teletherapy		
	• Telecobalt units	243	
	• Gamma Knife units	07	
	• Super Gamma System	01	
	• Accelerators	194	
	• Tomotherapy	03	
	• Cyber Knife	02	
	Brachytherapy		
	• High Dose Rate	181	
	• Low Dose Rate	14	
	• Manual(Intracavitary)	62	
	• Manual (Interstitial)	20	
	• Sr-90 Ophthalmic Applicators	19	
	• Ru-106 Ophthalmic Applicators	02	
	• I-125 Ophthalmic Applicators	03	
	• I-125 seeds for Prostrate Implant Applicators	01	
4	**Nuclear Medicine**		
	• Diagnostic low dose therapy		139
	• Diagnostic low & high dose therapy	Not applicable	40
5	Research centres using unsealed radioisotopes	Not applicable	238
6	Radio Immuno Assay (RIA)	Not applicable	231
7	Medical cyclotrons	11	11
8	**Industrial Radiography**		
	• Radiography Camera	1972	
	• X-ray units	263	436
	• Accelerators	13	

9	Gamma Irradiators	17	17
10	X-ray Beam Irradiators	05	04
11	Gamma Chambers	135	110
12	Nucleonic Gauges	8612	1638
13	Well Logging	257	48
14	**Consumer Products** • Gas Mantle • Lamp starters • Smoke Detectors • Electron Capture Detector (ECD)	Not applicable	 31 13 104 876

3.2 APPROVALS AND CONSENTS

3.2.1 Type Approvals

In order to ensure the radiation doses received by workers and members of the public do not exceed the prescribed dose limits and further that such doses are kept As Low As Reasonably Achievable (ALARA), design safety is accorded primary importance and operational control measures are monitored. With this in view, all devices incorporating radioactive sources, including radiation generating equipment are subjected to a type approval procedure. AERB permits only type-approved devices to be marketed and used in India. The criteria for type approval are stipulated in the Standards Specifications (SS) documents for a variety of devices. These SS documents are periodically reviewed and revised, where necessary, in order to meet currently accepted international standards. Safety Review Committee for the Application of Radiation (SARCAR) examines the design safety features of each device and recommends issuance of type approval. SARCAR held four meetings during the year. Based on the recommendations of SARCAR, AERB issued type approval certificates to the manufacturers/suppliers of devices incorporating radioactive materials and radiation generating equipments. Number of the devices type approved during the year is given in Table 3.2.a. No Objection Certificates (NOC) issued for procurement of certain equipment are given in Table 3.2.b and the consents issued are given in Table 3.2.c.

Table 3.2.a: Number of Type Approvals Issued (January to December 2010)

Sr. No.	Type of Equipment	Number of Models Type Approved
1	Medical Diagnostic X-ray units	10
2	Computed Tomography (CT) Units	02
3	Interventional Radiology Units	01
4	Tele Cobalt Units	01
5	Medical Linear Accelerators	02
6	Remote Controlled Afterloading Brachytherapy Units	03
7	Industrial Gamma Radiography Exposure Devices (IGRED)-Renewal	03
8	Approval of Classification for the Design of Sealed Sources	25
9	Industrial Radiation Gauging Devices (IRGD)	26
10	X-ray baggage information system	23
11	Gamma Chambers	06

Table 3.2.b:
NOCs issued for Import (January to December 2010)

Sr. No.	Type of Equipment	Number of NOC Issued
1	Computed Tomography (CT) Units	02
2	Interventional Radiology Units	05
3	SPECT-CT Units	01
4	PET-CT Units	01
5	Medical Linear Accelerators	03
6	Remote Controlled Afterloading Brachytherapy Units	04
7	Gyro Knife Unit	01
8	Gamma Ray Stereotactic Neurosurgery System	01
9	Industrial Gamma Radiography Exposure Device / source Changer Models	03
10	Mobile Industrial radiography X-ray Units	01
11	Industrial radiography X-ray Units	03

Table 3.2.c:
Consents Issued (January to December 2010)

Sr. No.	Type of Application	Permission Granted
1	Site Approval for installation of Gamma Radiation Processing Facility	5
2	Design and Construction Approval for Gamma Radiation Processing Facility	2
3	Renewal of Licence for routine operation of Gamma Radiation Processing Facility	2
4	Certificate of Approval for radiation processing of food products to Gamma Radiation Processing Facility	4
5	Commissioning Approval for Medical Cyclotron Facility	3
6	Site, Design and Construction Approval of 14 MeV D-T Neutron Generator Facility	1
7	Permission for supply the new remote control unit and guide tube applicable to industrial gamma radiography exposure device (IGRED) model GAMMARID- 192/120	1

3.2.2 Approval of Radiological Safety Officers

The approval certificates issued to Radiological Safety Officers (RSOs) are given in Table 3.3.

Table 3.3: Approval Certificates Issued to RSOs (January to December 2010)

Sr. No.	RSO Level	Number Approved
1	RSO Level-III (Radiotherapy)	160
2	RSO Level-III (Industrial Radiography)	09
3	RSO Level-III (Gamma Irradiators)	11
4	RSO Level-II (Industrial Radiography)	120
5	RSO Level-II (Nuclear Medicine Diagnosis)	58
6	RSO Level-I (Nucleonic Gauge)	180
7	RSO Level-I (Research Applications)	32
8	RSO Level-I (Well Logging)	20
9	RSO Level-I (Ship Breaking)	02
10	RSO Level-I (Container scanner)	02

3.2.3 Approval of Packages for Transport of Radioactive Material

Various packages used for transport of radioactive material, that are covered under transport regulations are, Excepted Packages, Industrial Packages, Type A Packages, Type B(U)/(M)/C Packages. Graded approach is applied in evaluating the performance standard of package designs/regulatory approval for the packages. 'Type A' packages, which are used to transport radioactive material of activity not exceeding the specified limits (A1/A2 values), need to be registered with AERB. All 'Type B' packages are subjected to a stringent approval procedure and are required to fulfill the regulatory standards.

During the report period, registration certificate was issued to one Type A package. Renewal of approvals for three Type B (M) packages and for seven Type B(U) were issued. New Design Approval were issued to one Type B(M) package and two Type B(U) packages.

3.3 LICENSING / AUTHORISATION

3.3.1 Licensing / Authorization

Licenses for operation were issued to three medical cyclotrons and two high intensity Gamma Radiation Processing Facilities (GRAPF).

AERB issued 521 regulatory licenses as Certificate of Registration to diagnostic X-ray installations upon confirming that the applicable regulatory requirements are duly satisfied. 41 NOCs were issued for the export of radioactive sources. 172 NOCs were issued for transfer of sources abroad for disposal. Details of Licences/NOCs issued during the year 2010, are given in Table 3.4.

Table 3.4: Licences / NOCs Issued (January to December 2010)

A. Procurement of Sources

Sr. No.	Type of application	Regulatory Licences / NOC	
		Local	Import
1	**Radiotherapy**		
	• Telecobalt	16	04
	• Accelerators	-	33
	• Gamma Knife	-	-
	• Tomotherapy	-	-
	Brachytherapy		
	• HDR	-	173
	• LDR	-	-
	• Manual (Intracavity & Interstitial)	03	-
	• Opthalmic Sr-90	-	-
	• Opthalmic I-125	04	03
	• Ophthalmic Ru-106	-	-
2	**Nuclear Medicine**		
	• RIA facilities	12	78
	• Diagnostic & Therapeutic	264	233
	• Research	94	250
3	Industrial Gamma Radiography Exposure Devices	1046	239
4	Gamma Irradiators (Category-IV)	09	-
	Gamma Irradiators (Category-I)	04	01
5	Nucleonic Gauges	53	180
6	Well Logging	-	69
7	Diagnostic X-ray (Registration)	521	-
	CT and Cath lab units (License)	141	-
8	**Consumer Products**		
	• Gas Mantle	19	-
	• Lamp starters	02	-
	• Electron Capture Devices	17	90
	• Smoke detectors	-	12
	• Explosive detectors	-	70

B. Number of Sources Disposed off at Different Disposal Agencies

BRIT	WMD, BARC	CWMF, Kalpakkam	ECIL, Hyderabad	Original Supplier Abroad	NAPS, Narora
403	87 6945(ICSD) 690.2 kg(DU)	686	4	272	130

Note: DU : Depleted Uranium and ICSD : Ionisation Chamber Smoke Detector

3.3.2 Shipments under Special Arrangement

Consignments, which do not meet all the normally applicable requirements of the transport regulations due to specific reasons, are permitted to be transported under special arrangements, which include provision of compensatory safety measures achieved through operational controls. Five such shipments were approved during the year.

3.4 REGULATORY INSPECTIONS

Compliance assurance is one of the main objectives of regulatory inspection. Details related to regulatory inspections during the year are given in Table 3.5. As seen in Fig. 3.1, there has been a substantial increase in the number of inspections in radiation facilities in the last year.

Table 3.5: Regulatory Inspections (January to December 2010)

Sr. No.	Facilities	Number of institutions	Number of Inspections
1.	Diagnostic X-ray	~ 50,000	102
2.	Radiotherapy	306	46
3.	Nuclear Medicine	162	52
4.	Industrial Radiography	436	78
5.	Gamma Irradiators	17	09
6.	Nucleonic Gauges	1638	23
7.	Well Logging	48	12
8.	Gamma Irradiation Chamber	110	61

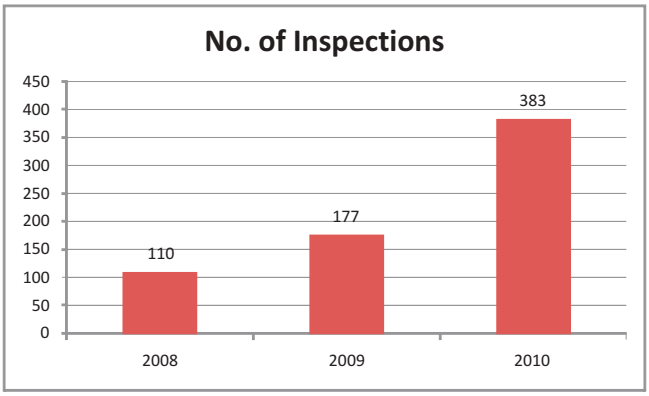


Fig. 3.1: No of Regulatory Inspections carried out in Last 3 Years

3.5 SAFETY SURVEILLANCE OF RADIATION FACILITIES

Two industrial gamma radiation processing facilities were issued license for operation during the period January to December 2010. With this, there are now seventeen industrial gamma radiation processing facilities in operation in India. Over 2945 licenses were issued for procurement of radiation sources, 33 licenses were issued for procurement of linear accelerators and over 268 authorizations were issued for disposal of sources in India and abroad. A total of 521 certificates of registration and 141 licences were issued to diagnostic X-ray installations.

Regulatory inspections were conducted in various radiation facilities and three unusual occurrences related to loss or misplacement of radiation sources were investigated. Fifty six permissions were issued for transport of radioactive material. Five shipments were approved to be transported under special arrangement. Awareness programmes for regulatory requirements and radiation safety in the fields of radiography, research application of radioisotopes, oil well logging, thorium nitrate user industries etc were conducted.

Following are the detailed radiation safety status of the above said facilities for the period January to December 2010.

3.5.1 Radiation Diagnostic and Therapy Facilities

On the basis of pre-commissioning safety evaluation, AERB issued authorizations for the commissioning of 50 teletherapy units (9 telecobalt units, 40 medical LINAC and one tomotherapy unit) and 22 remote after-loading brachytherapy units, and for the decommissioning of 8 teletherapy units during the year. Permissions were accorded for re-starting 6 telecobalt units after source replacement. Fifty two nuclear medicine facilities were inspected. AERB reviewed annual safety status reports received from the licensees and inspected 102 medical X-ray diagnostic installations. Deviations and violations of regulatory requirements were taken up with the users. In some cases, AERB initiated appropriate regulatory actions such as suspension of license.

3.5.2 High Intensity Gamma Irradiation Facilities

Regulatory inspections were carried out at seven operating gamma irradiation facilities. Inspections were carried out at the operating gamma irradiation facilities.

Nine proposals for the loading/ replenishment of Cobalt-60 sources from such facilities were reviewed and

clearances were issued. Sites for installation of five more such facilities have been approved.

3.5.3 Industrial Radiography Facilities

There are 436 industrial radiography institutions operating in India. The total number of industrial gamma radiography exposure devices deployed for radiography work is 1972. There are 263 Industrial X-ray units and 13 industrial accelerator facilities. During the year, AERB carried out announced as well as unannounced inspections of 78 industrial radiography sites and installations. The monthly safety status reports received from radiography institutions were reviewed to ensure availability of safety infrastructure and inventory of radiography devices/sources. Type approval applications for three new models of radiography devices were reviewed and approved. A total of 1285 authorisations were issued for source replenishment in the IGREDs.

3.5.4 Nucleonic Gauging Facilities

AERB carried out inspections of 23 institutions using nucleonic gauging devices. Safety status reports from these installations were reviewed to ensure availability of safety infrastructure and inventory of nucleonic devices/sources. A database of the nucleonic devices housing radioactive sources used by the various industrial and research institutes in India is being maintained.

3.5.5 Gamma Irradiation Chambers/Blood Irradiators

There are 135 gamma irradiation chambers/ blood irradiators in operation in the country. The layout of the installation wherein the gamma chamber would be installed needs approval. In case of decommissioning of the gamma chamber, prior approval required to be taken. The unit should be dismantled only after safe removal and transfer of the source(s) for safe disposal.

3.5.6 Transport of Radioactive Materials

Fifty six permissions for transport of radioactive material were issued during the year. AERB communicates regularly with other government authorities for the safe transport of radioactive material in and out of the country. The concerned nodal and other agencies are Director General of Civil Aviation (DGCA), New Delhi, Port Trusts, Indian Railways, Airport Authority of India and Customs.

3.5.7 Disposal of Radioactive Materials

The users send decayed radioactive materials from medical, industrial and research institutes for safe disposal to the original supplier or to one of the approved radioactive waste disposal facilities in India. The number of authorizations issued for export to original supplier abroad was 172.

Before the issuance of authorization for transport of radioactive material for disposal, in authorized disposal agencies in India, safety assessment of the disused sources are done by physical inspection, correspondence with the waste generator and the authorized waste management agency. A total of 96 such authorizations were issued in the report period.

3.6 UNUSUAL OCCURRENCES AND ENFORCEMENT ACTIONS

All unusual occurrences at radiation facilities were reviewed in the AERB Standing Committee for Investigation of Unusual Occurrences in Radiation Facilities (SCURF). As per the recommendations of the committee, enforcement actions were taken against the concerned institutions. Following are the details of the unusual occurrences in the report period.

3.6.1 M/s. NDT Systems, Mumbai informed AERB about loss of their IGREDs model Teletron Sr. No.841462 and model Sentinel Delta 880 Sr. No. 4744 containing 555 GBq and 333 GBq Ir-192 sources respectively, from source storage pit room at M/s. Bina Oman Refinery Project Ltd., Bina on February 08, 2010. Subsequently, the above devices were recovered on the same day by the personnel of M/s. NDT Services, Mumbai within the premises of M/s. Bina Oman Refinery Ltd. The devices were found to be intact and in good condition. After recovery, the IGREDs were stored in the source storage room at M/s. Bina Oman Refinery Project Ltd., with adequate physical security measures.

3.6.2 The incident involving serious radiation injuries to a person was reported to AERB on April 7, 2010. On investigation of this incident it was found that the main cause of incident was due to handling of bare Co-60 sources of Gamma Cell-220 belonging to University of Delhi, Delhi. This gamma cell was auctioned by University of Delhi on February 26, 2010. The unit was dismantled in Mayapuri Scrap yard causing the overexposure to seven persons. Out of seven one person succumbed to radiation injuries. A show-cause notice/directive was issued vide letter dated April 29, 2010 to suspend all the activity involving the use of radiation sources in possession of University of Delhi. After compliance with all the stipulated regulations University of Delhi was issued licence for handling low activity sources. Action has also been initiated under relevant sections of Atomic Energy Act in this regard.

3.6.3 An incident of missing of five number of nucleonic gauges from M/s National Aluminum Company Limited (NALCO), Damanjodi, Koraput, Orissa, was reported on October 5, 2010. The five gauges containing Cs-137 source were found to be missing after they were dismantled and stored for safe disposal. A show-cause notice was issued on October 21, 2010. M/s NALCO replied to show-cause notice vide letter dated Nov. 02, 2010. Two of the RSD officers were deputed on Nov. 11, 2010 to investigate and search the missing gauges. The incident was discussed in 36th meeting of Standing Committee for Investigation of Unusual Occurrences in Radiation Facilities (SCURF) held on December 9, 2010. Efforts are still on to locate and recover the sources.

3.7 ACTIONS INITIATED BY AERB FOLLOWING MAYAPURI SCRAP YARD INCIDENT AT DELHI

The incident, involving serious radiation injuries to a few persons, occurred at Mayapuri, Delhi in April 2010. In addition to the regulatory actions taken against the responsible facility, AERB initiated many actions to prevent recurrence of such incidents. The actions are summarized below:

- AERB initiated several steps to strengthen the inventory of the sources including the legacy sources. The details are:
  - All the known suppliers of gamma cells and other radiation sources world-wide were contacted to give details of the sources supplied by them over the years so as to verify with existing inventory with AERB.
  - Ministry of Steel, Ministry of Health and Family welfare, Ministry of Coal, Ministry of Power and University Grants Commission (UGC) were requested to issue circulars to units under them to come forward with details of used / disused sources. In addition, letters were issued by AERB to the universities for submitting the details of radioactive sources available with them.
  - Users of the sources were informed with the help of print media to furnish information on sources in their possession.
  - AERB has initiated the process of developing a computerized web-based system for managing the regulation of radiation sources and facilities.
- Awareness / Training programs on handling of radioactive material for research and training activities were conducted at various universities.
- Fourteen awareness programs were conducted in the field of industrial radiography, oil well logging, nucleonic gauges, gas mantles manufacturing industries, diagnostic radiology, medical cyclotron facilities, transport of radioactive material and research facilities handling radioactive material.
- In order to detect sources at the shops / facilities / dealing with metallic scrap efforts are on to persuade the scrap associations and dealers to install the radiation monitoring instruments to check the presence of radiation in the scrap.
- Awareness programs are being conducted by AERB in co-ordination with Engineering Export Promotion Council (EEPC) on radiation protection issues at Regional / Local levels for scrap dealers and manufacturers.
- AERB has established Regional Regulatory Centers (RRCs) at Southern and Eastern Region to make the regulatory process more effective.
- AERB has also augmented trained man power to deal with regulation of radiation facilities more effectively.
- As a part of its compliance assurance program, AERB has significantly increased the number of inspections for radiation facilities.
- As recommended by AERB, through Department of Atomic Energy, action has been initiated by relevant authorities to install high sensitivity radiation monitoring systems at all major sea ports and air ports.
- A committee has been constituted to streamline arrangements for disposal of used sources; the committee has representation from all concerned agencies.
- AERB has drafted legislation for compensation to victims of radiation injury. Further, Department of Atomic Energy is in the process of finalizing these draft rules.

3.8 OTHER ACTIVITIES

3.8.1 Inspection of the site, where the high energy x-ray based cargo scanning system which was proposed to be installed at New Delhi for the Common Wealth Games before issuing the approval of the site, was carried out. Permission for regular operation of the system was issued after the safety assessment of the scanner and radiation survey of the location.

3.8.2 After receiving request from Pipavav Port,

Gujarat regarding possible presence of radioactive contamination in two metal scrap containers, inspection was carried by officers from AERB. After inspection, both the containers were found to be free of radioactive contamination.

3.8.3 After getting inputs from Director General, Federal Agency for Nuclear Control, Belgium, regarding shipment of a radioactive contaminated scrap container, to an Indian Company, AERB requested the Indian Customs at JNPT to hold the container for inspection. After inspection by a team of officers from RSD, AERB and RSSD, BARC, presence of natural thorium was confirmed. AERB advised the importing institution to re-export the scrap container.

3.8.4 During the period AERB responded to two emergency calls regarding finding of drum with radiation warning symbol in grocery shops in Malad and Thane area of Mumbai. Officers from AERB were deputed for investigation along with officers from BARC to these locations. After search, empty containers which previously contained thorium nitrate were found in the grocery shops. The empty drums were confiscated and brought to BARC for safe disposal. AERB has advised the user facilities for safe disposal of the empty drums.

To curb recurrence of such incidents in future, AERB requested IREL, the supplier of thorium nitrate, to give unique identification number to the drums and maintain a log book for the drums supplied with respect to the user facilities, so that the traceability of the purchaser is possible. IREL agreed to the same.

3.9 FORMATION OF DIRECTORATE OF RADIATION SAFETY

In view of a very large number of x-ray based diagnostic installations in India, for better regulatory control, AERB proposed establishment of Directorate of Radiation Safety (DRS) in 1985 in all the States and Union Territories of India. In line with the proposal, AERB is coordinating with all the States and Union Territories for establishment of DRS. Presently, DRS has been functional in the State of Kerala. Regarding other States and Union Territories, the proceedings are detailed below:

- MoU has been signed between Govt. of Mizoram and AERB on March 25, 2010 for formation of Directorate of Radiation Safety.
- MoU has been signed between Govt. of Madhya Pradesh and AERB on May 25, 2010 for formation of Directorate of Radiation Safety.
- Communications have been established with the Health Secretary, Gujarat regarding formation of Directorate of Radiation Safety, Gujarat.
- Meeting was held with Health Secretary, Government of Karnataka regarding the formation of DRS along with copies of MoU.
- Communications have been established with the Health Secretary, Lakshdeep Islands regarding formation of Directorate of Radiation Safety.
- Meeting with Secretary of Health & Family Welfare of Punjab, Haryana and Chandigarh on October 5-7, 2010 respectively regarding formation of DRS.

3.10 REGIONAL REGULATORY CENTRES (RRC) OF AERB

In order to have effective regulation on radiation and nuclear facilities, AERB has proposed to establish three RRCs in the country. Southern Regional Regulatory Centre (SRRC) at Kalpakkam and Eastern Regional Regulatory Centre (ERRC) at Kolkata have already been initiated. In addition one more Regional Centre in north region is also proposed to be set up in XII plan period.

3.10.1 Southern Regional Regulatory Centre (SRRC)

Currently two officers and one scientific assistant from AERB are deputed to the SRRC. Various regulatory inspections of the radiation facilities located in this zone were conducted. The details of inspection are radiotherapy centers (11), nuclear medicine centers (3), industrial radiography centers (5), diagnostic radiology centers (7) and gamma chamber installations (2).

The inspection reports with the observations and recommendations were submitted to AERB for further action.

3.10.2 Eastern Regional Regulatory Centre (ERRC)

ERRC started functioning from VECC, Kolkata. Currently one officer is deputed to ERRC. In addition to the inspection of nuclear facilities located in this zone, inspections of radiation facilities were conducted. The details of such inspections are radiotherapy centers (3), nuclear medicine centers (2), industrial radiography centers (2) and radiation processing plants (1).

CHAPTER 4

INDUSTRIAL SAFETY

AERB carries out review and monitoring of industrial safety status in nuclear power plants/ projects, nuclear fuel cycle facilities and other associated facilities of DAE through Industrial Plants Safety Division (IPSD), AERB. Industrial safety with respect to construction and fire safety aspects of new projects are being reviewed by IPSD. The industrial safety aspects of operating units along with significant events and fire incidents are reviewed by the Division, unit safety committees and SARCOP.

Licenses are issued/renewed and regulatory inspections of all DAE units are carried out under the Factories Act, 1948 and the Atomic Energy (Factories) Rules, 1996.

Regulatory inspections for industrial & fire safety aspects were strengthened through monthly inspections at projects for effective monitoring and rectification of 'unsafe acts & unsafe conditions' to ensure adequate level of industrial safety at the construction sites.

Competent persons are designated for various DAE units under the Factories Act, 1948 (as amended in 1987) and Rule 31 of the Atomic Energy (Factories) Rules, 1996 for the purpose of carrying out tests, examinations and inspections under various sections of the Factories Act, 1948, namely for civil construction & structural work, operation of dangerous machines, lifts and hoists, lifting machinery and lifting tackles, pressure plant, dangerous fumes, supervision of handling of hazardous substances and ventilation system. Sixty persons were designated as competent persons under various sections of the Factories Act, 1948.

Certifying surgeon is appointed under Section 10 of the Factories Act, 1948 (as amended in 1987) and under Rule 5 of Atomic Energy (Factories) Rules, 1996 by AERB for carrying out the duties prescribed in Rule 7 of Atomic Energy (Factories) Rules, 1996. Two doctors were appointed by AERB as certifying surgeon at various DAE units.

A Fatal Accident Assessment Committee (FAAC) constituted by AERB reviews the fatal accidents at DAE units and gives recommendations. The recommendations made by FAAC are further discussed in respective Advisory Committees / SARCOP and Board of AERB.

4.1 LICENSES ISSUED UNDER FACTORIES ACT

The following licenses for operation were renewed/ issued to various DAE units.

- Operating license for Turamdih mill of UCIL for five years.
- Operating license for ECIL, Hyderabad renewed for five years.
- Operating license for HWP-Talcher (including new operating facilities) renewed for five years.
- Operating license for Jaduguda mill renewed for five years.
- Operating license for HWP-Kota renewed for five years.
- Operating license for HWP-Manuguru renewed for five years.
- Operating license for RAPP 5 & 6 issued for five years.

4.2 REGULATORY INSPECTIONS

For improving industrial safety status of construction sites, monthly inspections at construction sites of nuclear power projects and quarterly inspections at construction sites of various fuel cycle facilities and other R & D units were carried out to ensure safety requirements (with emphasis on safety in work at height). Monthly industrial safety status reports from all major construction sites are received and reviewed along with compliance of recommendations of previous monthly regulatory inspections.

Regulatory inspections on industrial & fire safety aspects under the Atomic Energy (Factories) Rules, 1996 and Factories Acts, 1948 along with radiological safety and waste management aspects were carried out at various DAE units.

During the year, 125 regulatory inspections, including 43 monthly inspections at construction sites of nuclear power projects (including regulatory inspections) and 5 quarterly inspections of fuel cycle facilities

construction sites were carried out. During these inspections, the inspectors ensured immediate rectification of the unsafe conditions and unsafe acts observed. During the inspection, any safety related incident and near miss incidents are also reviewed. The compliance to the findings of these inspections and the AERB directives has improved the overall safety culture of the units. Some of the significant improvements at the operating plants and construction project sites are given below.

- At HWPs, Hazard and Operability (HAZOP) study is being ensured for all modifications. Internal audits are being periodically conducted and most of the pending in-service inspections of equipment / piping identified in first cycle have been completed.

- At NFC, Hyderabad, the minimum safety precautions needed at construction sites as per AERB notification dated November 29, 2004 for construction activities are being followed at construction sites namely, new chlorination facility, occupational health centre and helium backfilling chambers.

- At ECIL, Hyderabad, the meeting of sectional safety committees are being periodically conducted, fire fighting arrangement are being provided at recommended areas like V Sat. monitoring room etc. and safety work permit system is being strictly followed for hazardous job.

- At UCIL, Turamdih Mill, fire hydrant system has been commissioned and improvements are being made in the dust extraction system in the fine crushing area to prevent spreading of dust.

- At IREL, Udyogamandal, fire call points are being installed in the relocated MPP. Radiological work permit is being ensured for sealing jobs pertaining to trenches containing insoluble muck.

- IREL, OSCOM damaged vinyl sheets used for flooring and asbestos roof sheets are being replaced on priority. Filter cleaning procedure highlighting hazards and protections are being initiated.

- At KKNPP, based on review done by AERB on electric flash over incident, preventive measures like implementation of 'Electrical Safety Work Permit' system for all electrical jobs and use of personnel protection equipment are being strictly ensured.

- At all NPPs sites, compliance to Rule 11 of Atomic Energy (Factories) Rules, 1996 for illumination levels at various areas and implementation of safety checklist based on Job Hazard Analysis (JHA) is being ensured.

4.3 INDUSTRIAL SAFETY STATISTICS

The compilation of Industrial Safety Statistics-2010 of DAE units (other than BARC facilities and mines) provides the data on accidents and analysis of number of injuries and man-days loss caused by various factors.

There were 54 reportable injuries including 2 fatalities with a loss of 13724 man-days in 2010 in comparison with 68 reportable injuries including 10 fatalities with a loss of 72297 man-days in 2009. Both the fatalities occurred in nuclear power projects. Frequency Rate (FR) was 0.42 in 2010 as compared to 0.50 in 2009 which is a sign of improvement. The Severity Rate (SR) and consequently the Injury Index (I.I) for 2010 were also low as compared to 2009. The best performing year in terms of occupational injury statistics for DAE units was 2008 during the period of analysis (2001-2010) with its minimum of 0.03.

Statistics revealed that there was almost one reportable injury per 1000 employees since 2007 and an almost constant Frequency Rate at 0.5 since 2007 which calls for more proactive measures to reduce occupational injuries.

Incidence Rates (IR) of the DAE units were compared between similar industries across the country. The non-fatal Incidence rate in NPP was 0.27 as compared to 3.85 (2005) in other Electricity generation companies in India. The non-fatal Incidence rate in HWPs was 0.37 as compared to 1.76 (2005) in other chemical manufacturing units in India.

In 2010, 132 Near Miss Accidents (NMA) were reported from different units of DAE. 18 % of the reported near miss accidents were 'Fall of Objects' type and 12 % were 'Exposure to Electricity'. Analysis revealed that almost all 'Fall of Objects' type incidents were in construction projects and most of the 'Exposure to Electricity' types of incidents were in operating units. 'Fall of Objects' type NMA reported in 2009 was also at a maximum of 25 %.

It was observed that industrial safety performance of DAE units is better than other similar industries in the country. Table 4.1 gives the comparison of incidence rates in some DAE units with other similar industries in the country. Unit wise comparison of reportable injuries and man-days lost in 2010 is presented in Figs. 4.1 and 4.2 respectively. Unit-wise comparison of Injury Index and Frequency Rate are given in Figs. 4.3 and 4.4 respectively and year wise comparison of Injury Index in DAE Units is shown in Fig. 4.5.

In Figs. 4.6 to 4.8, distribution of injuries caused due to unsafe acts, injuries due to unsafe conditions and injuries with respect to the type of accidents in DAE units are reported.

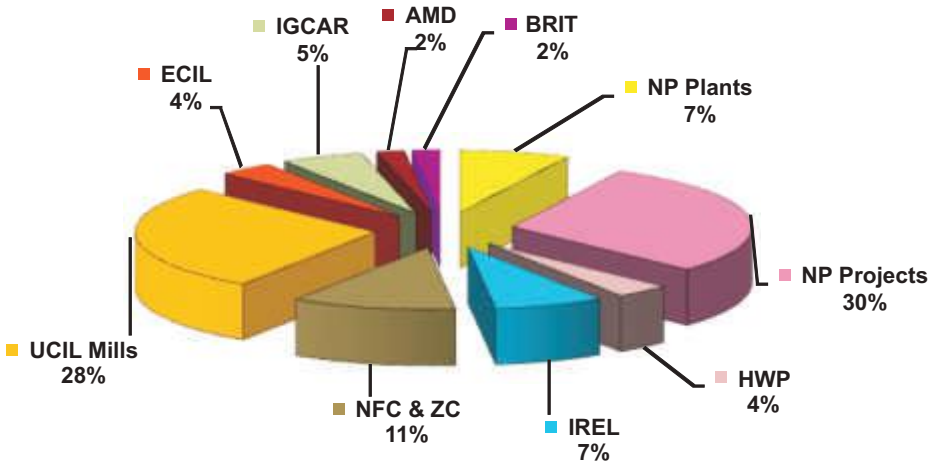


Fig. 4.1: Distribution of Reportable Injuries in DAE Units in 2010

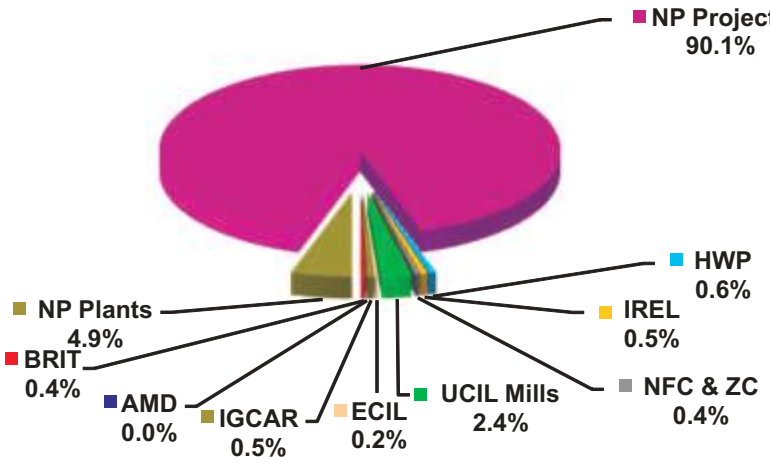


Fig. 4.2: Distribution of Man-days Loss in DAE Units in 2010

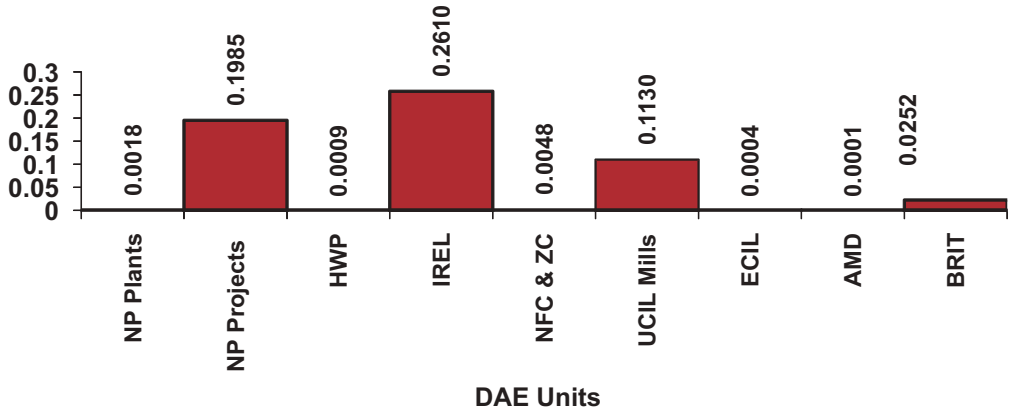


Fig. 4.3: Injury Index of DAE Units in 2010

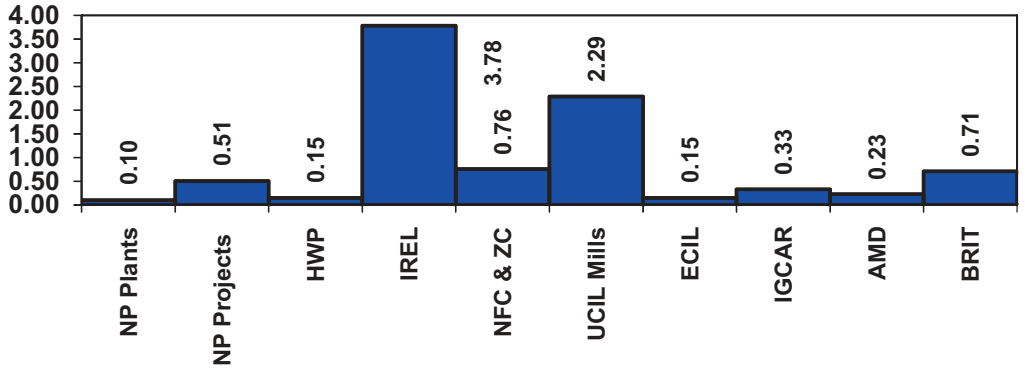


Fig. 4.4: Frequency Rates in DAE Units in 2010

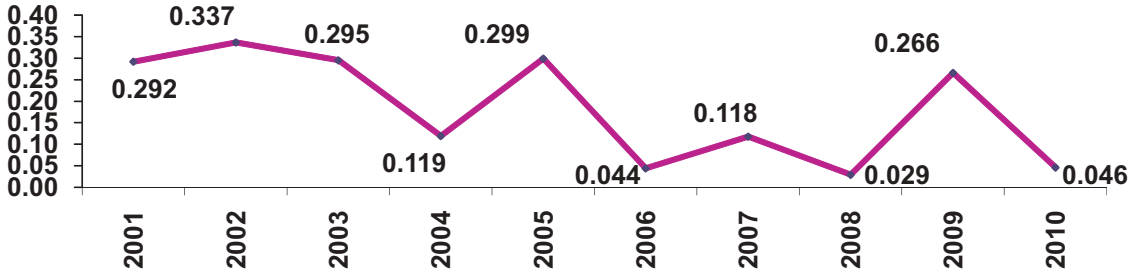


Fig. 4.5: Year wise Distribution of Injury Index in DAE Units

Table 4.1: Comparison of Incidence Rates of DAE Units (2010) with Equivalent Non-DAE Industries (2005)

Comparison of Incidence Rates of DAE Units with Equivalent Non-DAE Industries (obtained from Pocket Book of Labor Statistics 2008)		
Industry Type	**Incidence Rate**	
	Fatal	**Non-Fatal**
Heavy Water Plants (2010)	0	0.37
Manufacture of Chemicals & Chemicals products (2005)	0.15	1.76
Nuclear Fuel Complex (2010)	0	1.50
Manufacture of Fabricated Metal Products except Machinery and Equipment (2005)	0.10	1.81
Nuclear Power Plants (2010)	0	0.27
Electricity, Gas, Steam and Hot water supply (2005)	0.25	3.85

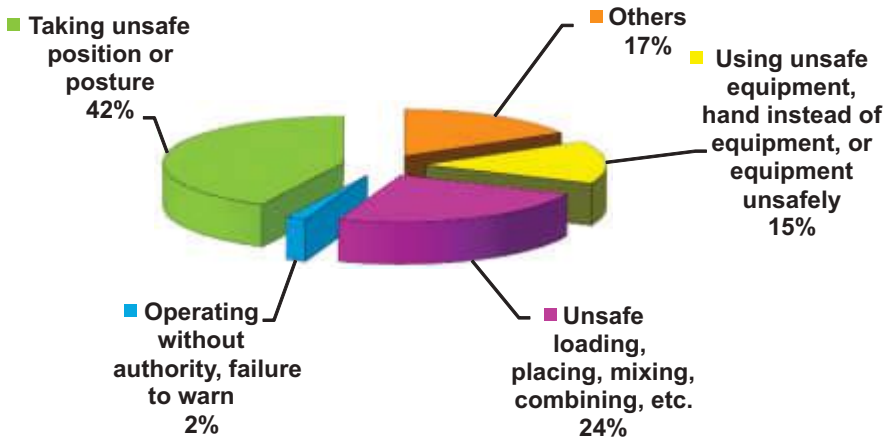


Fig. 4.6: Distribution of Number of Injuries caused due to Unsafe Acts in DAE Units-2010

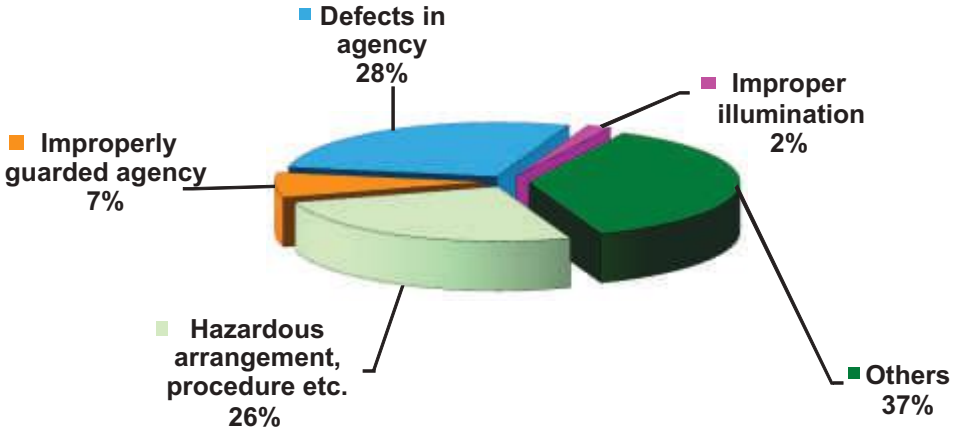


Fig. 4.7: Distribution of Number of Injuries caused by various Unsafe Conditions in DAE Units- 2010

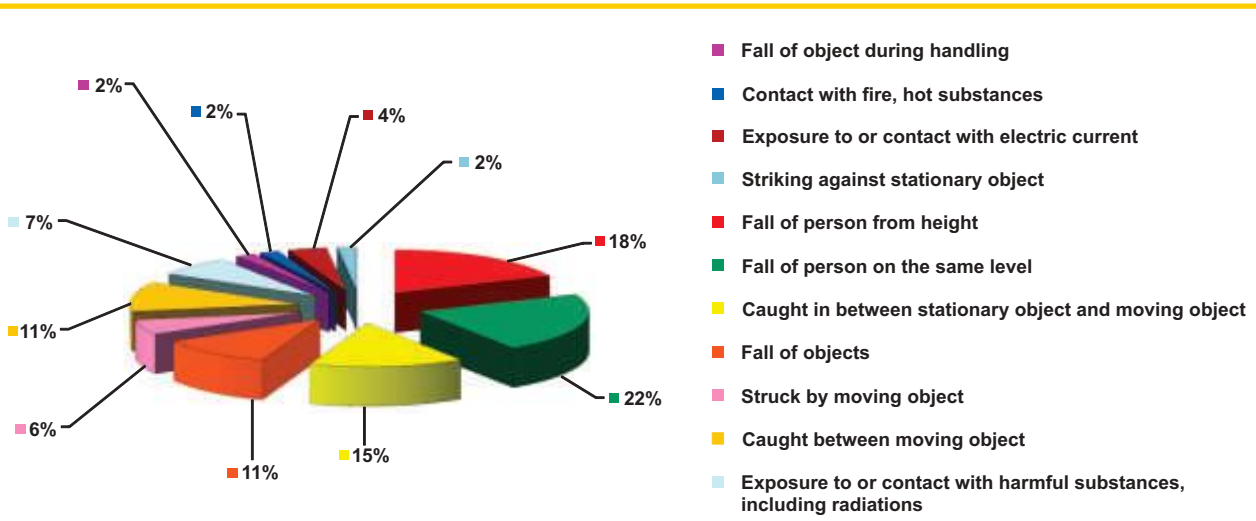


Fig. 4.8: Distribution of Injuries with respect to the Type of Accidents causing Injuries in DAE: 2010

4.4 FATAL ACCIDENTS

There were three fatal accidents at construction sites during the year (April 2010-March 2011) at KK-NPP and PFBR, BHAVINI construction sites. These accidents were investigated to arrive at the root cause and remedial measures were suggested to the sites to prevent recurrence.

A summary of these accidents along with review and recommendations / directives of AERB is given below.

On August 28, 2010 at central workshop building of KKNPP, one contract worker engaged in the job of painting of the north wall of the above-mentioned building, fell down from a height of 13 m EL. The incident took place when the victim tried to anchor his safety belt on to the outer horizontal member of the scaffold, standing on the un-secured working platform. During this, the working platform slipped off the scaffold and the victim lost his balance and fell down from 13 m elevation. On the spot assessment of the incident was done by an AERB officer and subsequently reviewed in the FAAC. AERB asked the occupier to implement remedial measures such as strict adherence to safety work system after proper assessment of the hazards involved in the job; the executive agency shall ensure provision of safe access to the working area, guarded working platforms, life line (horizontal), safety nets and personal fall arrester system and verification of the same by the safety group during the work at height; ensuring proper arrangements for proper lifting of the paint cans from ground floor to higher elevation and ensuring safety supervision by the contractor & NPCIL officers executing the job along with safety group during hazardous jobs.

On February 17, 2011 at Caisson structure area of PFBR, BHAVINI, while dismantling the gantry structure erected for caisson launching in the off shore end of jetty, one metal channel slipped from the metal basket and fell down from the top of gantry over the walkway platform made on the annular gap of caisson top and hit the head of the victim. The victim succumbed to injuries after 10 days. On the spot assessment of the incident was done by an AERB officer and subsequently reviewed in the FAAC. AERB asked the occupier to implement remedial measures such as usage of closed metal basket designed for lifting heavy gantry bracing material, strengthening of medical emergency management & communications system at work locations and improvement in safety supervision by department and contractor at such vulnerable areas.

On February 19, 2011 at Reactor Building no. 1 of KKNPP, one welder engaged in welding job at 14 m EL of the Reactor Building 1 was found dead in the loop-4 area. Post mortem report of the victim indicated hypoxia (lack of oxygen) in the heart and lungs which confirmed the death on electrocution. On the spot assessment of the incident was done by an AERB officer and subsequently reviewed in the FAAC. AERB asked the occupier to implement remedial measures such as carrying out jobs involving helpers/un-skilled workers under strict supervision of skilled workers and work supervisors, strict adherence to periodicity of surveillance of electrical equipment/portable electric tools as per Indian Electrical Rules - 1956 by KKNPP electrical department and departmental electrical personnel should ensure safe working conditions at work site with respect to electrical systems/ equipment and certify the same.

4.5 PROMOTION OF INDUSTRIAL SAFETY

4.5.1 DAE Safety and Occupational Health Professionals Meet

The 27th DAE Safety & Occupational Health Professionals meet was jointly organized by AERB, Mumbai and Nuclear Fuel Complex (NFC), Hyderabad at NFC, Hyderabad during November 25 – 27, 2010. The themes for this year's meet were 'Chemical Safety, Waste Management' for Industrial Safety and 'Industrial Toxicology' for Occupational Health Safety. Dr. S.S.Ramaswamy memorial endowment lecture was delivered Dr. K. V. Ragahavan, Distinguished Professor, Indian National Academy of Engineering (INAE), Board Member of AERB and HWB and Former Director, Indian Institute of Chemical technology.

A booklet on 'Chemical Safety & Waste Management' was released during this meet. The Green Site awards, which consider various factors like effective site area, efforts taken to improve the greenery, etc., were presented. The winners of this awards for the year 2009 were NFC, Hyderabad and IREL Manavalakurichi in Category A (<=400 hectares) and IGCAR site in Category B (> 400 hectares). In view of the excellent performance of IREL OSCOM which has been winning this award in succession for the last few years, it was decided to declare IREL OSCOM as an 'Evergreen Site'.

4.5.2 Industrial Safety Awards

AERB presents Industrial Safety awards every year to the DAE Units who achieve high levels of performance in Industrial Safety. For the year 2010, Heavy Water Plant – Manuguru and Tarapur Atomic Power Station-3 & 4 in Production Units–I Group, Nuclear Fuel Complex, Hyderabad (Radioactive plants) in Production Unit-II and Indian Rare Earths Ltd., OSCOM (Thorium Plant) in the Research /Low Risk Units Group were the winners. The awards were presented to the winners along with Fire Safety awards for the year 2010 in the month of April, 2011.

Industrial and Fire Safety Award Function in Progress
(Shri S. K. Chande, Vice-Chairman, AERB, Shri R. Bhattacharya, Secretary, AERB, Director, IPSD and ITSD and Shri G. Nageswara Rao, Director (O), NPCIL are seen along with winners)

4.5.3 Fire Safety Awards

The Fire Safety awards are decided by taking into account the preventive efforts taken by the site, the fire incidents that had occurred during the period under consideration and the fire potential at the site. DAE units are categorized based on fire potential as Category-I (all operating NPP, HWPs and NFC) and Category –II (IREL units, UCIL units, NPPs under construction, BHAVINI, RRCAT, VECC, BRIT, AMD, IGCAR and ECIL) and accordingly two awards are given in each category. In Category I joint winners were HWP-Kota and MAPS and in Category II, VECC, Kolkata was the winner.

4.5.4 Green Site Awards

The Green Site awards for the year 2009 was given to winning units during the 27th DAE Safety and Occupational Health Professional Meet, which was held at NFC, Hyderabad during November 25-27, 2010. The award is based on the highest value of Greenery of the site, which takes into account the existing greenery area, efforts made for making the site greener, terrain conditions of the site and effective site area. The DAE units are divided into two categories based on the total area of the plant including housing colony site, namely, Category-A (<350 hectares) and Category-B (>350 hectares). Based on these criteria, in Category-A, NFC, Hyderabad and IREL-Manavalakurichi and in Category-B, IGCAR, Kalpakkam site were the winners.

In view of the excellent performance of IREL OSCOM which has been winning this award in succession for the last few years, it was decided to declare IREL OSCOM as an 'Evergreen Site'.

A working group to study feasibility of establishing a new 'Environmental Protection Award' instead of Green Site Award has been constituted by AERB.

4.6 OCCUPATIONAL HEALTH

4.6.1 Advisory Committee on Occupational Health

The Advisory Committee on Occupational Health (ACOH) for employees of DAE units reviews their occupational health records, recommends measures to ensure their health, informs AERB of any observed case of occupational diseases and suggests ways to improve the occupational health activities. No occupational diseases were reported during 2010-11 from any of the DAE units. The committee discussed on the analysis of 'Yearly Occupational & Health Status' report for the year 2010 and 'Emergency Medical Management' for radiation emergency based on the recent accident that occurred at Fukushima Daiichi nuclear power plants in Japan due to impact from unprecedented combination of multiple events of earthquake and tsunami on March 11, 2011. A two-member committee was formed to review the availability of antidotes required for management of radiological emergencies at occupational health centres of all NPCIL sites.

Based on the recommendation of ACOH, AERB and the Variable Energy Cyclotron Centre, Kolkata in association with B.P. Poddar Hospital and Medical Research Centre at Kolkata conducted a Training Programme / Workshop on 'Management of Medical Emergencies including cases of Poisoning' and on 'Stress Management' for the benefit of Para medical staff and Certifying Surgeons working in the Occupational Health Centres / First Aid Centres of the DAE units. The workshop was conducted during August 28 - 29, 2010. Fifteen certifying surgeons and eighteen para-medical staffs of different DAE units attended the workshop.

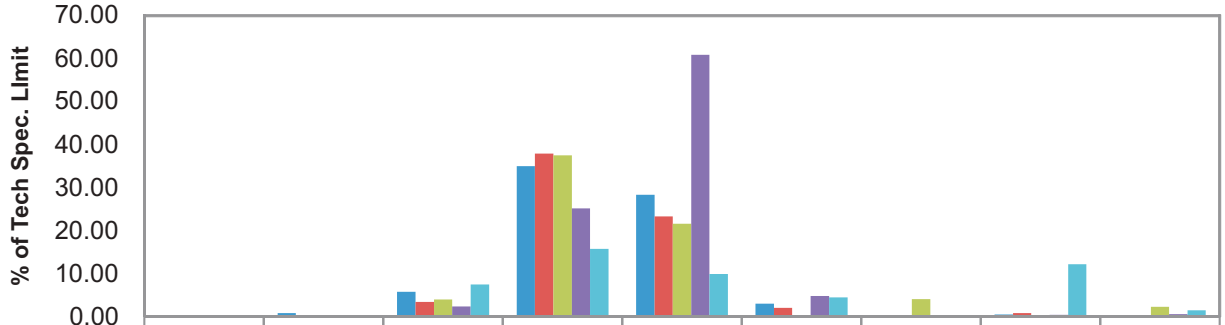
CHAPTER 5

ENVIRONMENTAL SAFETY AND OCCUPATIONAL EXPOSURE

5.1 ENVIRONMENTAL SAFETY

The Environmental Survey Laboratories (ESL) of the Health, Safety and Environment Group, BARC carry out environmental surveillance at all the operating nuclear power plant sites. The liquid and gaseous waste discharged to the environment during year 2010 from the operating units was only a small fraction of the prescribed technical specification limits. The technical specification limits on release of radioactive effluents for all the nuclear power stations were revised with effect from January 1, 2010. This has resulted in increase of discharges of some of the effluents, in term of the percentage of technical specifications limits in the year 2010 as compared to the previous years. The absolute discharges from all NPPs were, in general, similar to those in the previous years. Figs. 5.1a - 5.1e show the liquid and gaseous discharges from the plants for the years 2006, 2007, 2008, 2009 and 2010 as percentage of permissible limits as per technical specifications. Figs. 5.2a and 5.2b show the committed effective dose to the members of the public due to the release of radioactive effluents from the plants. Radiation dose to members of the public near the operating plants is estimated, based on measurements of radionuclide concentration in items of diet, i.e., vegetables, cereals, milk, meat, fish, etc and through intake of air and water. It is seen that in all the sites the effective dose to public was far less than the annual limit of 1 mSv (1000 micro-Sievert) prescribed by AERB.

Fig. 5.1 a: Liquid Waste Discharges from NPPs (Tritium)

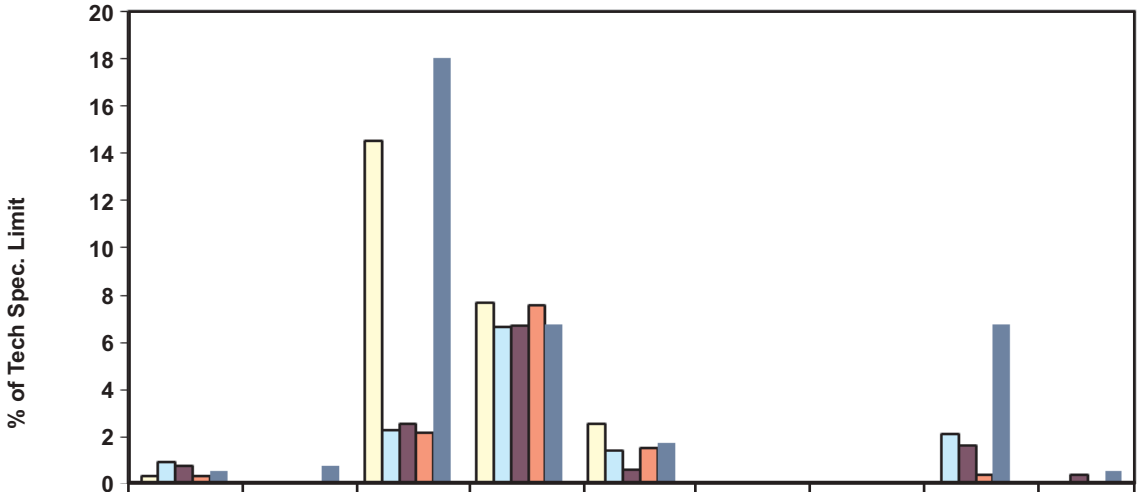


	TAPS 1&2	RAPS 1&2	MAPS	NAPS	KAPS	KGS 1&2	RAPS3&4	TAPS 3&4	KGS 3&4
2006	0.00	0.91	5.81	34.91	28.32	3.07	0.18	0.58	
2007	0.00	0.32	3.50	37.83	23.28	2.12	0.19	0.87	
2008	0.00	0.08	4.05	37.46	21.55	0.13	4.15	0.41	2.32
2009	0.00	0.33	2.40	25.13	60.68	4.89	0.29	0.46	0.66
2010	0.00	0.42	7.50	15.73	9.91	4.50	0.24	12.22	1.53

Notes:

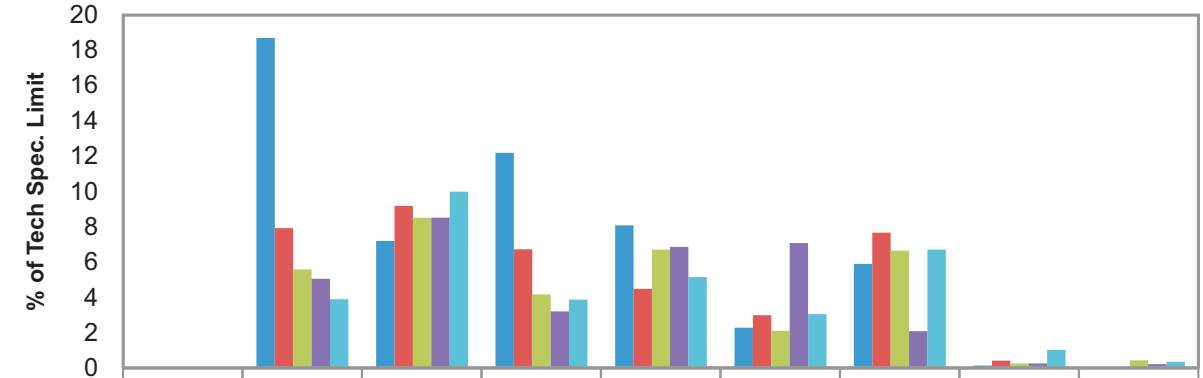
1) TAPS 1&2 has Boiling Water Reactors. Hence, there is no generation / discharge of tritium.
2) The data of MAPS pertains to transfer of liquid waste to Centralised Waste Management Facility, Kalpakkam for processing & discharge to the environment.
3) In KAPS-1, suppression pool was dewatered during the year 2009 and 71.25 TBq of tritium activity was released as liquid effluent after obtaining approval from AERB.

Fig. 5.1 b: Liquid Waste Discharges from NPPs (Gross Beta)



	TAPS 1&2	RAPS 1&2	MAPS	NAPS	KAPS	KGS 1&2	RAPS 3&4	TAPS 3&4	KGS 3&4
2006	0.37	0.07	14.49	7.67	2.56	0.00	0.08	0.12	
2007	0.96	0.01	2.29	6.65	1.44	0.00	0.06	2.16	
2008	0.82	0.009	2.60	6.74	0.65	0.01	0.03	1.65	0.41
2009	0.37	0.07	2.20	7.60	1.56	0.01	0.02	0.45	0.11
2010	0.77	0.77	18.00	6.78	1.77	0.032	0.10	6.78	0.57

Fig. 5.1 c: Gaseous Waste Discharges from NPPs (Tritium)

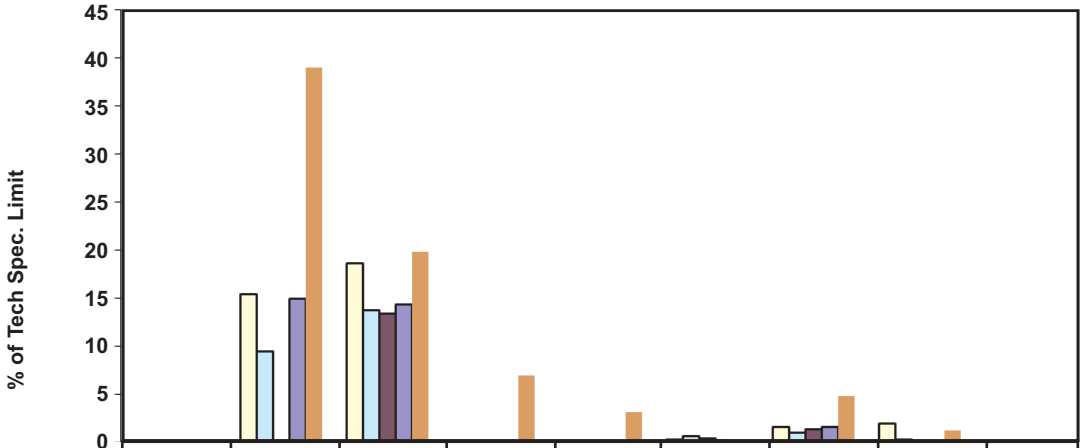


	TAPS 1&2	RAPS 1&2	MAPS	NAPS	KAPS	KGS 1&2	RAPS3&4	TAPS 3&4	KGS 3&4
2006		18.65	7.18	12.16	8.07	2.27	5.88		
2007		7.89	9.17	6.70	4.47	2.98	7.64		
2008		5.57	8.50	4.16	6.68	2.09	6.63	0.25	0.44
2009		5.04	8.50	3.19	6.84	7.06	2.08	0.25	0.22
2010		3.89	9.96	3.86	5.13	3.03	6.69	1.01	0.35

Note:

TAPS 1&2 has Boiling Water Reactors. Hence, there is no generation / discharge of Tritium.

Fig. 5.1 d: Gaseous Waste Discharges from NPPs (Argon-41)

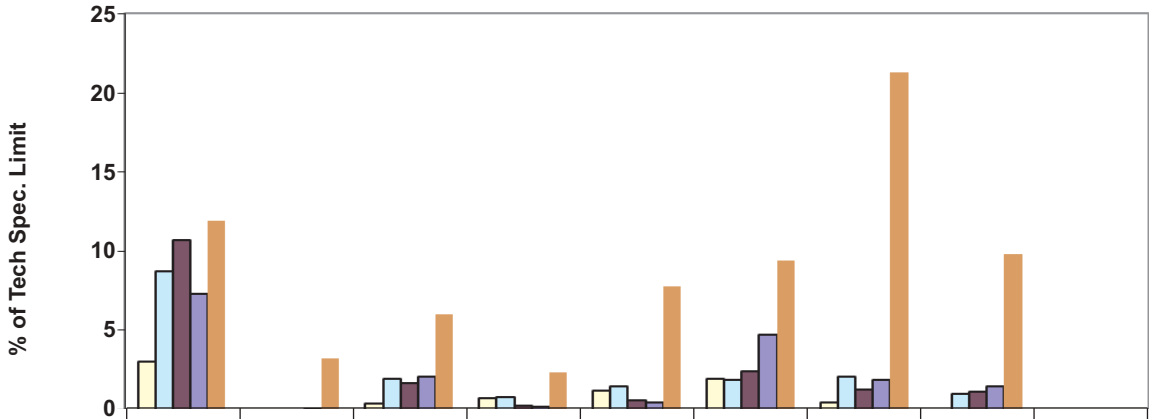


	TAPS 1&2	RAPS 1&2	MAPS	NAPS	KAPS	KGS 1&2	RAPS 3&4	TAPS 3&4	KGS 3&4
2006	0.00	15.45	18.65			0.34	1.66	1.97	
2007	0.00	9.52	13.77			0.73	1.13	0.32	
2008	0.00	0.00	13.34			0.36	1.29	0.06	0.02
2009	0.00	15.00	14.3			0.15	1.63	0.04	0.08
2010	0.00	39.04	19.87	6.96	3.16	0.13	4.84	1.22	0.03

Note:

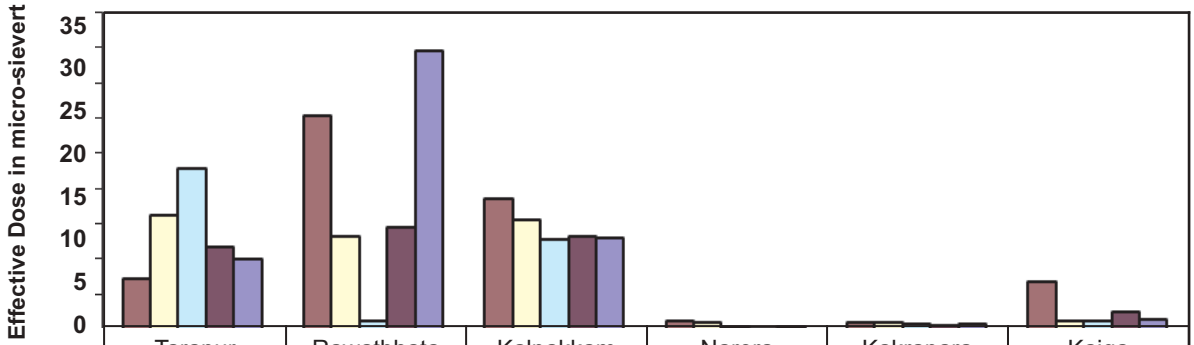
1) Ar-41 releases are less from NAPS reactors onwards because of their operation with filled calandria.
2) Discharge of Ar-41 was controlled under the technical specification limit for FPNG at NAPS & KAPS upto the year 2009 and included in the FPNG releases in Fig. 5.1.e. Separate limit on Argon-41 release was prescribed in the Technical Specifications of NAPS and KAPS from January 2010 onwards.

Fig. 5.1 e: Gaseous Waste Discharges from NPPs (Fission Product Noble Gases)



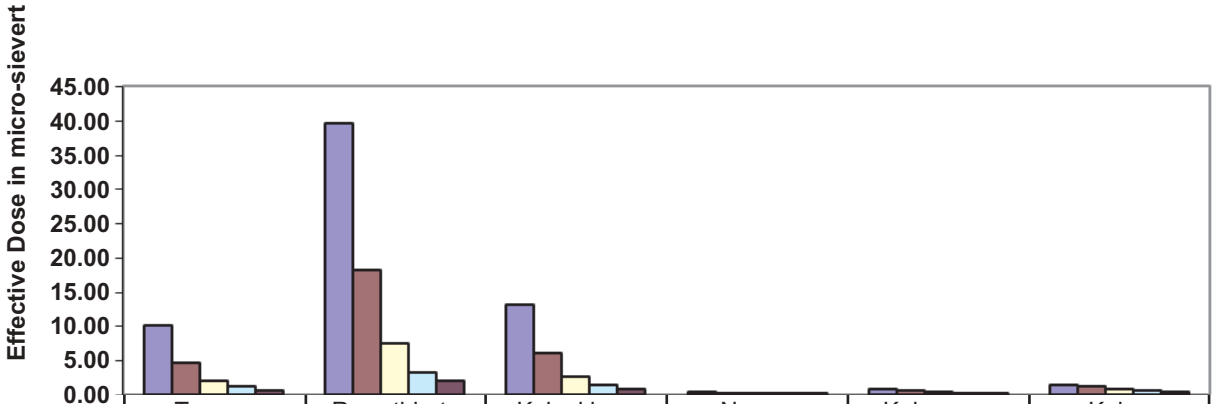
	TAPS 1&2	RAPS 1&2	MAPS	NAPS	KAPS	KGS	RAPS 3&4	TAPS 3&4	KGS 3&4
2006	3.04	0.00	0.40	0.77	1.20	2.00	0.50	0.00	
2007	8.71	0.00	0.95	0.84	1.47	1.92	2.12	1.00	
2008	10.68	0.00	1.70	0.29	1.64	2.46	1.28	1.14	0.003
2009	7.32	0.05	2.10	0.19	1.43	4.70	1.91	1.45	0.00
2010	11.94	3.26	6.00	2.38	7.77	9.43	21.3	9.81	0.05

Fig. 5.2 a: Public Dose at 1.6 km Distance from NPPs
(AERB Prescribed Annual Limit is 1000 micro-Sievert)



	Tarapur Site	Rawatbhata Site	Kalpakkam Site	Narora Site	Kakrapara Site	Kaiga Site
2006	7.215	30.40	18.68	1.18	1.12	6.91
2007	16.25	13.30	15.60	1.05	1.00	1.26
2008	23.00	1.26	12.80	0.48	0.79	1.31
2009	11.82	14.60	13.20	0.30	0.60	2.48
2010	10.15	39.60	13.12	0.42	0.75	1.47

Fig. 5.2 b: Total Effective Dose in Different Zones
(AERB Prescribed Annual Limit is 1000 micro-Sievert)



	Tarapur Site	Rawatbhata Site	Kalpakkam Site	Narora Site	Kakrapara Site	Kaiga Site
1.6km	10.15	39.00	13.12	0.42	0.75	1.47
1.6-5km	4.50	10.20	6.02	0.29	0.56	1.21
5-10km	1.94	7.40	2.53	0.20	0.33	0.78
10.15km	1.14	3.20	1.40	0.19	0.28	0.53
15-30km	0.62	1.00	0.71	0.18	0.28	0.35

5.2 OCCUPATIONAL EXPOSURES

In each NPP, a Radiological Safety Officer (RSO) and Assistant RSO are designated by Chairman, AERB to implement the radiation protection programme. The RSOs are entrusted with the responsibility of providing radiological surveillance and safety support functions. These include radiological monitoring of workplace, plant systems, personnel & effluents, carrying out exposure control, exposure investigations & analysis and trending of radioactivity in plant systems.

All NPPs have radiation safety programme and work procedures intended to control the occupational exposures. AERB Safety Manual on 'Radiation Protection for Nuclear Facilities' (AERB/NF/SM/O-2 Rev.4, 2005) specifies Dose Limits and Investigation Levels (IL) for occupational workers to control the individual doses. As per AERB guidelines, for an occupational worker annual dose limit is 30-mSv, with the condition that it should not exceed 100 mSv in a span of 5 years. The specified annual limit for radiation exposure of temporary worker is 15-mSv. For better exposure control, the individual cases are investigated and controlled at an early stage so as to avoid reaching the AERB specified dose limits. Following ILs are applicable to the nuclear facilities.

Monthly dose - 10 mSv

Quarterly dose - 15 mSv

Annual dose - 20 mSv

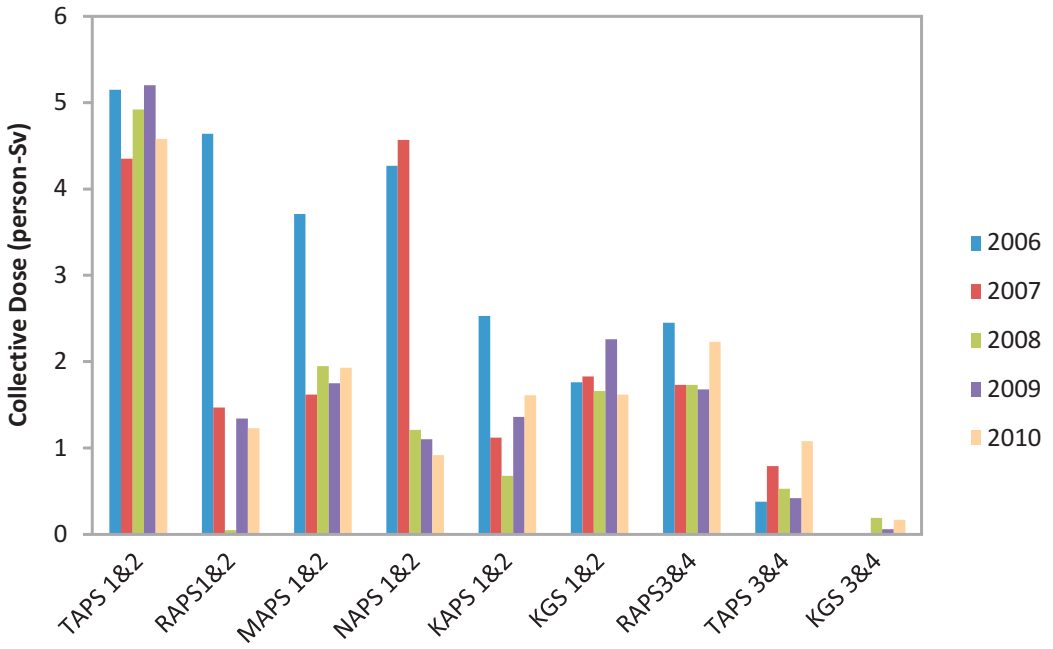
The information on number of workers in NPPs who received dose less than 20 mSv, between 20 to 30 mSv and above 30 mSv during the year 2010 is given in Tables 5.1. There was no case of overexposure to occupational worker during the year 2010 beyond the limits prescribed by AERB. However, there was one case of temporary worker exceeding the annual limit with a radiation exposure of 16.42-mSv while working at calandria vault repair job in KAPS-1.

Table 5.1: Radiation Doses Received by Workers in NPPs

NPP	Number of monitored persons	Average dose for monitored persons (mSv)	Number of persons received dose	Average dose among dose receivers (mSv)	Number of workers received dose in the range		
					< 20 (mSv)	20-30 (mSv)	>30 (mSv)
TAPS-1&2	1742	2.63	1372	3.34	1372	0	0
RAPS-1&2	1096	1.13	722	1.71	722	0	0
MAPS-1&2	1220	1.58	1031	1.87	1031	0	0
NAPS-1&2	1505	1.78	1209	2.21	1209	0	0
KAPS-1&2	1944	2.31	1590	2.82	1590	0	0
KGS -1&2	1515	1.07	1083	1.5	1083	0	0
RAPS-3&4	1715	1.3	1160	1.92	1160	0	0
TAPS -3&4	1452	0.75	1159	0.94	1159	0	0
KGS -3&4	1163	0.148	431	0.4	431	0	0

Fig. 5.3 gives collective dose for operation and maintenance of NPPs (excluding the dose for unit outage during special campaigns like EMCCR and EMFR) for last five year.

Fig. 5.3: Collective Dose (Person-Sv) at NPPs

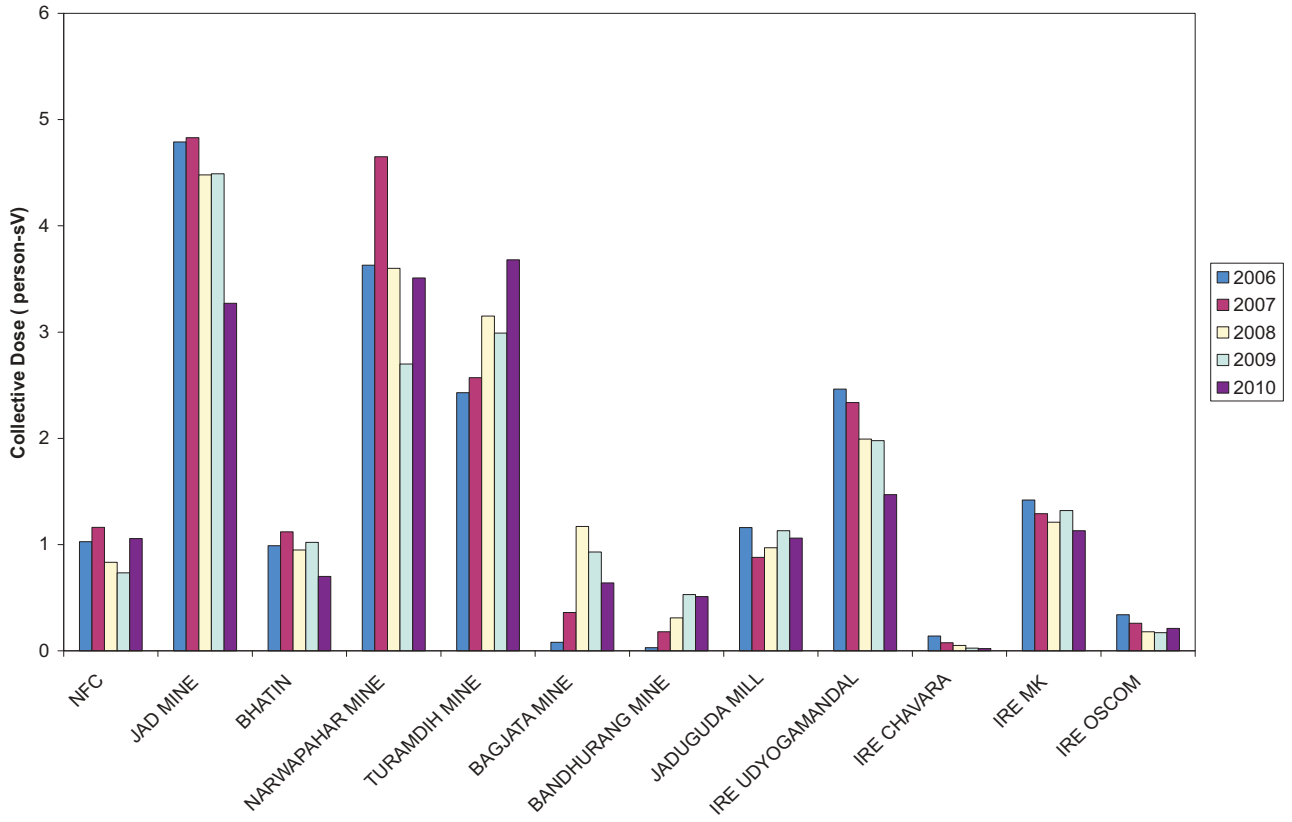


The information on number of workers in Front-end FCFs who received dose less than 20 mSv, between 20-30 mSv and above 30 mSv during the year 2010 is given in Table 5.2. There was no case of overexposure to occupational workers during the year 2010 beyond the limits prescribed by AERB. Fig. 5.4 gives the collective dose for Front-end Fuel Cycle Facilities (FCFs) for the last five years.

Table 5.2: Radiation Doses Received by Workers in Front end Fuel Cycle Facilities

Type of Facilities	Location	Number of Exposed Persons	Average Dose for Exposed Persons (mSv)	Maximum Dose of Exposed Persons (mSv)	Number of workers received dose in the range		
					< 20 mSv	20 – 30 mSv	>30 mSv
Uranium mines (UCIL)	Jaduguda	765	4.09	10.99	765	0	0
	Bhatin	188	3.72	6.91	188	0	0
	Narwapahar	678	4.83	7.58	678	0	0
	Turamdih	417	7.45	13.64	417	0	0
	Bagjata	150	2.76	3.64	150	0	0
	Banduhurang	35	1.57	1.85	35	0	0
Uranium mill (UCIL)	Jaduguda	475	1.75	4.99	475	0	0
Thorium mines	Chavara	55	0.4	0.82	55	0	0
	Chatrapur	160	1.17	9.51	160	0	0
	Manavalakurichi	193	5.82	13.67	193	0	0
Thorium mill (IREL)	Udyogamandal	311	4.3	15.62	311	0	0
Fuel fabrication (NFC)	Hyderabad	853	1.239	19	853	0	0

Fig. 5.4: Collective Dose for Front-end Fuel Cycle Facilities (FCFs) for the last five years.



The information on number of workers in medical, industrial and research institutions who received various doses during the year 2010 is given in Table 5.3. The number of radiation workers who received >30 mSv were: 2 out of 2431 in industrial radiation installations. The reason for the higher doses is attributed to wrong work practices by the radiation workers, which were brought out during investigations to avoid recurrence.

Table 5.3: Radiation Doses Received by Workers in Medical, Industrial and Research Institutions

Category of Radiation Worker	No. of Monitored Persons	Average Dose for Monitored Persons (mSv)	No. of Exposed Persons	Average Dose for Exposed Persons (mSv)	Number of Workers Received Annual Individual Dose Excluding Zero Dose, D(mSv)				
					0<D ≤20	20<D ≤30	30<D ≤40	40<D ≤50	D>50
Diagnostic X-rays	36371	0.34	16805	0.74	16796	9	0	0	0
Radiation Therapy	6921	0.22	3859	0.40	3859	0	0	0	0
Nuclear Medicine	1661	0.42	955	0.73	954	1	0	0	0
Ind. Radiography & Radiation Processing	6551	0.44	2431	1.20	2427	2	1	0	1
Research	3706	0.08	1014	0.31	1014	683	0	0	0

CHAPTER 6

EMERGENCY PREPAREDNESS

NPPs are provided with adequate safety features to guard against the possibility of any accident. Further, the safety features such as a containment building around each nuclear power unit helps in mitigating the consequences, should an event occur. However in the event of a beyond design basis accident, it might become necessary to take certain mitigating measures in the public domain. Site-specific emergency preparedness plans are therefore drawn up and maintained at all stations for plant emergencies, site emergencies and off-site emergencies. To test these plans, periodic emergency exercises are carried out involving the station authorities, district administration, and the members of public. Plant emergency exercises (PEE) are carried out once in a quarter by each NPP. Site emergency exercise (SEE) and Off-site emergency exercise (OSEE) are carried out by each site once in a year and once in 2 years respectively.

The number of site and offsite emergency exercises carried out in NPP sites in year 2010 is given in Table 6.1. The response of the plant personnel, district officials and public involved in the exercise was observed by AERB observers. The general level of response of the plant personnel, public and others showed continuous improvement as noticed from their orderly behaviour and evacuation. The countermeasures were implemented in the public domain by the district authorities promptly and efficiently.

Table 6.1: Number of Emergency Exercises conducted in year 2010

NPP Sites	No. of SEE	No. of OSEE
Tarapur Site	1	-
Rawatbhata Site	1	1
Kalpakkam Site	1	-
NAPS Site	1	-
Kakrapar Site	1	1
Kaiga Site	1	-

Periodic SEE and OSEE were carried out at hydrogen sulphide based HWPs at Manuguru and Kota. SEEs are carried out once in 6 months and OSEEs once in a year.

SEEs, PEEs and Fire drills are carried out at ammonia based HWPs at Baroda, Thal, Hazira and Tuticorin. PEEs are carried out once in a quarter and drills are carried out once in 2 months.

AERB officials witnessed the SEE and OSEE mock drills at some of the HWPs sites. The response of the plant personnel, officials and public involved in the exercise and general level of the awareness amongst the public were good. AERB constituted two committees to arrive at realistic concentrations of the toxic hydrogen sulphide gas in the event of release of complete inventory from HWP, Kota with respect to NPPs and of RAPP 7 & 8 and NFC, Kota to have comprehensive emergency preparedness plans.

CHAPTER 7

SAFETY DOCUMENTS

AERB develops safety documents, which include Safety Codes (SC), Safety Standards (SS), Safety Guides (SG), Safety Manuals (SM) and Technical Documents (TD) for nuclear and radiation facilities and related activities. The progress on various safety documents during the year is given below.

7.1 NEW SAFETY DOCUMENTS PUBLISHED

1. AERB/RF-MED/SC-1 (Rev. 1) - Radiation Therapy Sources, Equipment and Installations

With the advent of new techniques in radiation therapy during the last two decades and non-existence of codes for radiation generating equipment used in radiation therapy necessitated the revision of the safety code for 'Telegamma Therapy Equipment and Installations', (AERB/SC/MED-1) and safety code for 'Brachytherapy Sources, Equipment and Installations', (AERB/SC/MED-3) issued in 1986 and 1988 respectively. During revision it was considered to merge the codes into a single code titled 'Radiation Therapy Sources, Equipment, and Installations', covering the entire spectrum of operations ranging from the setting up of a radiation therapy facility to its ultimate decommissioning, including procedures to be followed during emergency situations.

The revised code covers radiation generating equipment such as medical accelerators, simulators and the latest technologies in radiotherapy which were not included in earlier codes. The revised code contains the contents of earlier codes with respect to safety specifications for radioactive sources, radiation therapy equipment and protective devices, radiation therapy installations, operational safety, patient protection, radiation protection programme, personnel requirements and responsibilities and regulatory controls. Considering the increased complexities in radiation therapy practices, a new section has been included emphasizing the need for quality assurance requirements in telegamma unit, accelerator, brachytherapy unit, simulator unit and treatment planning system. Further, the code introduces another section on management of radiation emergency.

In addition to the above, the code prescribes performance requirements for radiation therapy sealed sources, limits of leakage radiation levels for radiation therapy equipment and accessories, dose rate limits for discharge of permanent implant patients, minimum qualifications and experience required for personnel in radiation oncology facility and responsibilities of personnel in radiation oncology facility.

2. AERB/RF-MED/SC-2 (Rev.2)-Nuclear Medicine Facilities

The first AERB safety code on Nuclear Medicine Facilities, AERB/SC/MED-4 was published in 1989 which was subsequently revised in 2001 as AERB/SC/MED-4(Rev.1), 2001. This code was then circulated for the comments and based on the comments received from the experts, a further revision was felt necessary. The code was further reviewed by the 'Safety Code Review Committee for Nuclear Medicine' constituted by Chairman, AERB to take into consideration the comments received during its circulation.

The pertinent suggestions obtained from various experts in the field were incorporated in the document and the same was reviewed again by AERB. The suggested modifications which were incorporated mainly pertain to:

- the educational qualifications of the staff of nuclear medicine facility: qualifications of the nuclear medicine technologists presently being accepted for in nuclear medicine,
- revision of limits for discharge of patients with radioactivity, and
- provision of delay tank facility in case of departments having high dose I-131 therapy for collection of radioactive effluents prior to release to municipal sewer.

3. AERB/RF/SG/G-3-Consenting Process for Radiation Facilities

This safety guide on 'Consenting Process for Radiation Facilities' provides explanatory details on information, review and assessment related to consenting process.

The objective of this guide is to apprise the applicant on details of the regulatory requirements in setting up a radiation facility. These include the regulatory consenting process, relevant stages requiring consent, wherever applicable, documents to be submitted and the nature and extent of review. The guide also gives information on the methods of review and assessment adopted by AERB. It is intended to assist the applicant to be fully prepared for the regulatory scrutiny and plan requisite actions accordingly in advance.

This guide deals with practices such as medical, industrial and research applications of radiation and radioisotopes for which the Consent is in the form of a Licence or an Authorisation. Other sources and practices for which Consent is in the form of a Registration/Approval are also covered in view of their widespread use (e.g. diagnostic X-ray facilities). In addition, it contains the forms and formats for submitting the information required for consenting.

4. AERB/FE&BE-FCF/SG-1 - Renewal of Licence for Operation of Nuclear Fuel Cycle Facilities other than Nuclear Power Plants and Research Reactors

Regulatory body grants initial licence for operation depending on safety review/assessment of project at commissioning stage as per AERB safety guide 'Consenting Process for Nuclear Fuel Cycle Facilities and Related Industrial Facilities other than Nuclear Power Plants and Research Reactors' (AERB/NF/SG/G-2) and renewal of licence is based on the review of plant performance. These guidelines describe different factors to be considered in comprehensive assessment of plant safety. The guidelines provide methodology for conducting periodic safety review for renewal of llicence of nuclear fuel cycle facility. The document covers the essential elements to be covered during renewal process within and beyond design life. The guidelines include review procedure, regulating criteria for renewal of licence, application form, structure for renewal of licence and time flow chart for processing.

5. AERB/NF/SM/CSE-4 - Regulatory Inspection during Construction of Civil Engineering Structures Important to Safety of Nuclear Facilities

This safety manual describes various aspects related to inspection by regulatory body during construction of civil engineering buildings and structures important to safety. Regulatory inspection consists of verifying compliance with regulatory requirements and continuous adherence to safety objectives of the nuclear facility under inspection. Inspection includes examination of the facility, ongoing activities, procedures, records, documents, surveillance and test procedures including results. The inspection also includes interviewing personnel, and witnessing tests and measurements. This manual exclusively mentioned the items to be inspected before, during and after the construction.

6. AERB/RF-RS/SG-1 - Security of Radioactive Sources in Radiation Facilities

The document addresses the radiological concerns / hazards associated with the unauthorised removal, sabotage and other intentional malicious acts during the handling of radioactive material which are used in medical, industrial and research applications. This document covers the processes to determine the level of security required for preventing malevolent use of sources throughout their lifecycle. It elaborates the basic principles of security, security culture and assessment of threat. This document also describes the desired security levels based on categorisation of the sources. It guides on administrative and technical measures. Appendices are enriched with dose criteria, categorization of sources and activities corresponding to dangerous sources.

7.2 SAFETY DOCUMENTS TRANSLATED AND PUBLISHED IN HINDI

1. Safety Guide titled 'Safety classification and seismic categorization for structures, systems and components of pressurized heavy water reactors (AERB/NPP-PHWR/SG/D1; 2003)'.
   'दाबित भारी पानी रिएक्टरों की संरचनाओ, तंत्रो तथा घटकों के लिए संरक्षा वर्गीकरण और भूकंपीय वर्गीकरण' पर संरक्षा संदर्शिका.

2. Safety Guide titled 'Quality assurance in the manufacture of items for nuclear power plants (AERB/SG/QA3; 1998)'.
   'नाभिकिय उर्जा संयंत्रो के सामग्री-निर्माण मे गुणवत्ता आश्वासन' पर संरक्षा संदर्शिका.

3. Safety standard 'Civil Engineering Structures Important to Safety of Nuclear facilities'
   'नाभिकिय सुविधाओं की संरक्षा हेतु महत्वपूर्ण सिविल इंजीनियरी संरचनाओ' पर संरक्षा मानदंड.

7.3 SAFETY DOCUMENTS UNDER DEVELOPMENT

1. Safety Code on 'Radiation Protection for Nuclear Facilities' (AERB/FE&BE-FCF/SC/RP)

2. Safety Guide on 'Development of Safety Documents for Nuclear and Radiation Facilities' [AERB/SG/G-6 (Rev. 1)]

3. Safety Guide on 'Classification of Radioactive Waste' (AERB/NRF/SG/RW-1)

4. Safety Guide on 'Materials of Construction for Civil Engineering Structures Important to Safety of Nuclear Facilities' (AERB/SG/CSE-4)

5. Safety Manual on 'Quality Assurance of Civil Engineering Structures Important to Safety of Nuclear Facilities' (AERB/NF/SM/CSE-3)

6. Safety Guide on 'Works Contracts' [(AERB/SG/IS-1 (Rev. 1)]

7. Safety Guide on 'Design of Nuclear Fuel Reprocessing Facilities' (AERB/BE-FCF/SG-1)

7.4 REVIEW OF IAEA DRAFT DOCUMENTS

The comments received from BARC, NPCIL and AERB on following IAEA draft documents were sent to DAE after review and compilation in AERB.

- Safety in Nuclear Power Plant : Design (DS 414)
- Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations (DS 417)
- Periodic Safety Review of Nuclear Power Plants (DS 426)
- Near Surface Disposal of Radioactive Waste (DS 356)
- The Use of a Graded Approach in the Application of the Safety Requirements for Research Reactors (DS 351)
- Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (DS425)
- Safety in the Utilization and Modification of Research Reactors (DS 397)

The following IAEA documents received by AERB for review are under process.

- Safety in the Use and Modification of Research Reactors (DS397)
- Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (DS 425)
- Fundamentals of a State's Nuclear Security Regime: Objective And Essential Elements

Following Document Preparation Profiles (DPP) from IAEA were reviewed and the comments were forwarded to IAEA.

- Radiation Protection of the Public and the Environment (DS 432)
- Radiation Safety of Radioisotope Production Facilities (DS 434)
- Regulations for the Safe Transport of Radioactive Material, 20XX Edition (DS 437)
- Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material, TS-G-1.1 (DS 425)
- Instrumentation and Control and Software Important to Safety for Research Reactors (DS 436)
- Site Survey and Site Selection for Nuclear Installations (DS 433)

CHAPTER 8

SAFETY STUDIES

8.1 SAFETY ANALYSIS

8.1.1 Seismic Re-evaluation of Fast Breeder Test Reactor (FBTR) at IGCAR, Kalpakkam

Seismic re-evaluation of FBTR undertaken as a R&D exercise jointly by AERB and IGCAR was completed. Seismic margin assessment (SMA) and seismic probabilistic safety assessment (SPSA), the two internationally accepted approaches for seismic re-evaluation were adopted to evaluate the seismic adequacy of FBTR. The exercise illustrated the method of accomplishing complete seismic re-evaluation of a nuclear facility by both the above approaches using the current state of art in India.

The criteria and methodology for seismic re-evaluation of FBTR was formulated, in line with internationally accepted practices and current safety requirements. A number of innovative approaches were worked out to apply the methodology to Indian scenario. The complete seismic re-evaluation of FBTR comprised of various steps like probabilistic seismic hazard analysis, seismic fragility evaluation of components and plants, estimation of seismic margin for the plant and assessment of seismic core damage frequency.

SPSA exercise of FBTR is the first comprehensive SPSA for a nuclear facility which was accomplished in India. Seismic PSA provided valuable insight to seismic induced accident sequences and major seismic risk contributors of FBTR. SPSA helped in identifying critical components of FBTR during a seismic event. Recommendations for upgrades in the plant were also derived from the results of seismic re-evaluation.

8.1.2 Tsunami Hazard Assessment of Indian Coast

Subsequent to the aftermath of 2004 Indian Ocean Tsunami, AERB recognized the need for a more rigorous treatment of tsunami hazard assessment of Indian coast and NPP sites in particular. Several activities were initiated for achieving this goal. First one among them was participation in to 'IAEA Extra Budgetary Project (IAEA-EBR) on Tsunami Hazard Assessment'. The EBP involved two activities:

- Tsunami hazard assessment.
- Post tsunami/earthquake considerations in surrounding area of the site.

As a part of the exercise, AERB carried out validation and tsunami hazard assessment of Kalpakkam site, where the scenario of tsunamis occurring along the tsunami genic zones around Indian coast were studied. The tsunami travel time from different tsunami sourses to locations along Indian coast, estimated as part of the study is given in Fig. 8.1 and Fig. 8.2. Based on the experience gained from this activity AERB is currently conducting a study on "Tsunami hazard assessment of Indian Coast". As part of this exercise, the following activities are currently being carried out:

- Characterization of Tsunami genic sources.
- Preparation of bathymetry and topographic data.
- Simulation of scenario tsunamis.
- Estimation of maximum wave heights along the coast.

The described activities are currently under progress.

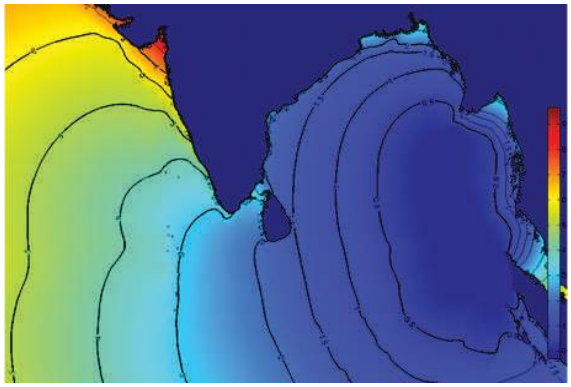


Fig. 8.1: Tsunami wave travel time estimates from Andaman-Sumatra region to various locations along Indian coast (contour lines correspond to 0.5, 1, 1.5, 2, 3, 4, 5, 6 Hrs)

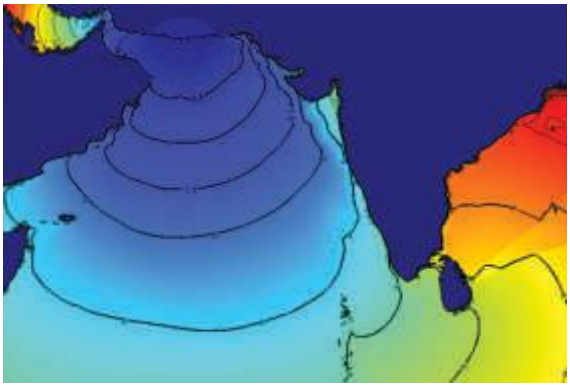


Fig. 8.2: Tsunami wave travel time estimates from Makran region to various locations along Indian coast (contour lines correspond to 0.5, 1, 1.5, 2, 3, 4, 5, 6 Hrs)

8.1.3 SBO Analysis of 540 MWe TAPS-3&4 PHWR

Station blackout (SBO) analysis for 540 MWe TAPS-3&4 was carried out without taking credit of manual crash cool down. The purpose of this analysis is to check the capacity of instrumented relief valve on the reactor outlet headers. TAPS-3&4 540 MWe is pressure tube type, heavy water moderated and heavy water cooled reactor. It has two loops with each having 196 channels. Various systems such as primary heat transport systems (reactor inlet and outlet headers feeders, end fittings, primary circulating pumps etc) secondary system (steam generator, feed line, steam line, safety valves, turbine governor valves etc.), pressurizer, bleed condenser etc.. required for the analysis are simulated. Turbine, feed flow to steam generators (SGs), primary coolant pumps (PCPs) and reactor trip occur due to the event. Primary heat is removed through atmospheric steam discharge valves till the SG inventory reaches the minimum level. When SGs have no capacity to remove further primary heat then primary re-pressurization starts and instrumented relief valve (IRV) opens. It was predicted that maximum pressure in reactor outlet header is 110.6 kg/m^2 (g) where as IRV set point limit is 110 kg/m^2 (g).

8.1.4 External Coupling of 3-D Neutronics and Thermal-Hydraulics Codes

TRIHEXFA-RELAP Interface Program (TRIP) has been developed to integrate RELAP code with 3-D neutronics code TRIHEXFA. The external coupling methodology is used in TRIP. Spatial effect has been incorporated in the RELAP prediction through TRIP. Analysis of main steam line break (MSLB) accident of VVER-1000 has been carried out with TRIP. This analysis showed that coupling time is sensitive to the coupled code results. Reactor scram occurred in coupled code analysis few seconds earlier than stand alone RELAP analysis.

8.1.5 Fire Modelling of a Diesel Generator Room in a typical PHWR Plant

The fire modeling analysis of Diesel Generator (DG) room was carried out using Fire Dynamic Simulator (FDS-5.0). The main objective of fire modeling analysis was to analyze the temperature pattern near cable trays, detection time of smoke and heat detectors, effectiveness of CO_2 flooding system and also to estimate the time required to reach the damaging temperatures of cables. Major equipment such as DG rooms, location of louvers, locations of smoke and heat detectors and CO_2 flooding systems were modeled. Analyses were carried out in different combinations of louvers and CO_2 flooding system to see the temperature profile, smoke profile, and detection time of detectors. The fire hazard analysis would give time to failure of cable. The time data is used to determine probability of non suppression. This probability value along with generic DG room fire frequency data is used to get plant DG room fire frequency. Manual shutdown of the reactor would be needed following a fire event in DG room. The event tree for manual shutdown due to fire would give the contribution of DG room fire to overall plant core damage frequency.

8.1.6 Seismic Analysis of Liquid Storage Tank

A steel tank with water inside was analyzed for seismic loading. A 3-dimensional model was developed using code ANSYS. The tank is made of stainless steel with 7.5 m diameter and water partially filled up to a height of 8.6 m. Tank was modeled by both elastic shell and inelastic shell elements. The fluid and structure interaction was taken into account by coupling peripheral fluid element nodes with shell nodes. Bulk modulus & density of fluid, elastic modulus, density & poisson's ratio of tank material are fed. Coupling is done such a way that the fluid movement was constrained in radial direction where as it can move freely in tangential and axial directions. Modal analysis was done to find the fundamental frequency of vibration of tank and fluid together. Seismic response was found by response spectrum method and full non-linear method. The tank is attached to raft with 12 bolts; hence nodes at these locations are fixed. Nodes at all other locations are restrained in vertical direction. Tank, water, girder, roof are modeled by shell 183, fluid 80, beam 188 respectively. Static pressure variations along the axis of the tank was computed which matched with analytical calculation. The modes with significant mass participation are reported. The seismic signals available as acceleration – time history are applied at the base. Time history of the acceleration-time was used to find the time response of the forces and moments. Deformation behavior of the tank was obtained successfully.

8.1.7 Round Robin Exercise on Groundwater Modeling

BARC has floated a round robin exercise on groundwater modeling with the objective of 3-dimensional groundwater flow and containment transport modeling at the proposed uranium tailings pond in Turamdih, Jharkhand. Participants from different organizations like AERB, RSD-BARC, Dept. of Geology (Anna University), PSDD-BARC, EAD-BARC, SRI-AERB participating in the exercise.

A classical sample problem of 3-dimensional groundwater flow and contaminant transport for an unconfined aquifer having homogeneous and isotropic properties was solved with the objectives of calibrating the softwares/methodologies and to build confidence in data

simulation for actual problem. Amount of contamination transport through given aquifer after simulation of 60 years along with groundwater velocity was calculated. Fig. 8.3 shows AERB's study result on increase in groundwater velocities along distance and Fig. 8.4 shows time history of contaminant concentration along various observation points. These results of numerical studies were compared with the analytical solution.

Comparison of numerical results with analytical results showed that the amount of contaminant transported after 60 years simulation was over-predicted for the locations near to the contamination source (upto 3.0 km) by numerical analysis. For the far locations (beyond 3.0 km) the difference in predicted results are less. Whereas, comparison of groundwater velocity was found to be similar in numerical as well as in analytical result.

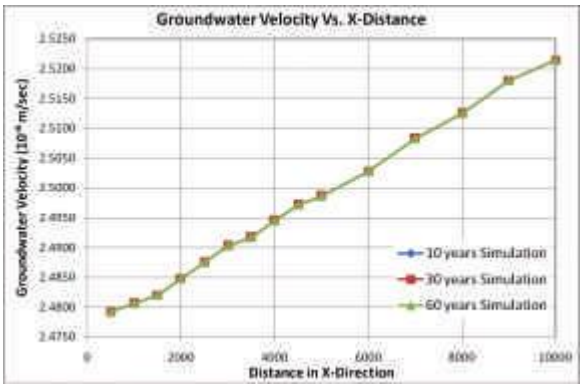


Fig. 8.3: Groundwater Velocities at 300m Depth

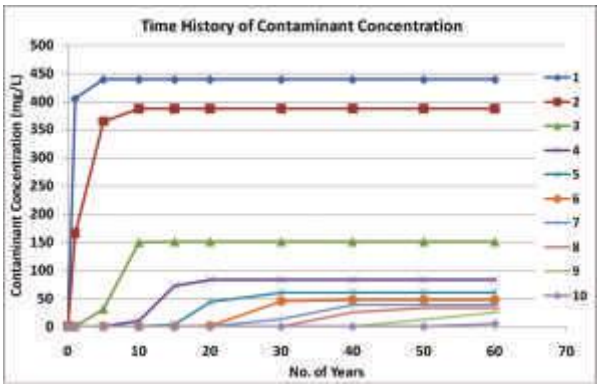


Fig. 8.4: Plot of Time History of Contaminant Concentrations for all the 10 Observations Points

8.2 SAFETY ANALYSIS REVIEW

8.2.1 Criticality Safety Review of Transport Cask

The criticality safety analysis and determination of criticality safety index of cask for PFBR fuel transportation was carried out. Possible accidental scenarios such as multiple birdcage stacking, water flooded condition, closed packed fuel containers without bird cage are considered. The predictions are in agreement with the values reported.

8.2.2 Criticality Safety Review of Transport Package for High Enriched Uranium Fuel Plates

Independent verification of the criticality safety calculation for the transportation package was carried out using computer code SCALE code system. These transport packages will be used for transporting high enriched uranium fuel plate to the away from reactor storage facility. All possible accident scenarios during transportation were considered for this analysis. It is found that SCALE code predictions are in good agreement with the reported values.

8.2.3 Review of Accident analysis of Final Safety Analysis Report of KK Project.

Final Safety Analysis Report (FSAR) is prepared by NPCIL considering recommendations of specialist group, core group and ACPSR-LWR during the review of preliminary safety analysis report and design changes made after the submission of PSAR. Accident analysis is carried out for postulated initiating events to demonstrate the adequacy of design of the plant including its safety systems to evaluate the radiological consequences to plant personnel on the installation and the public, as well as the potential effects on the environment. Review of various sections of the final safety analysis report (FSAR) is under progress. Compliance check for the comments and recommendations of specialist group and ACPSR-LWR are being carried out. Issues related to change in applicable ranges of DNBR correlations, RCP coast downtime, justification of use of point kinetics, and consequences of SG dry out, credit for normal operating system during accident conditions, best estimate analysis etc. were raised.

8.2.4 Review of Level-1 PSA for TAPS-1&2

The revised report on Level-1 PSA for TAPS-1&2 is being reviewed by AERB Committee on PSA. The committee made site visit and made some observations. The generic insights suggest that the peer review process needs to be strengthened.

8.2.5 ARA review of TAPS-1&2 and MAPS-1&2

The reliability analysis reports as a part of Application for Renewal of Authorization (ARA) for TAPS-1&2 and MAPS-1&2 were reviewed.

CHAPTER 9

SAFETY RESEARCH INSTITUTE

The focus of research activities at the Safety Research Institute (SRI), Kalpakkam has been in the following areas:

- Nuclear Safety
- Engineering Safety
- Environmental Safety

9.1 NUCLEAR SAFETY STUDIES

9.1.1 Reactor Physics and Radiological Safety

(a) Criticality Estimations for Initial 60 FAs Core loading Conditions of KKNPP

Monte Carlo (MC) calculations were carried out using Monte Carlo N-Particle code (MCNP) to estimate effective neutron multiplication factor (k-eff) for initial fuel loading conditions of VVER-1000 reactor, which is in advanced stage of commissioning in Kudankulam, Tamilnadu. KKNPP core is initially loaded with only 60 fuel assemblies (FAs) in their designated locations in almost dry conditions. The initial number of FAs is restricted to 60 FAs with the assumption that even in case of flooding the reactor core with unborated water of density 1g/cc, the core nuclear characteristics must ensure a sub-criticality of at least 2%. Present MCNP computations have been performed to check sub criticality conditions of initial 60 FAs loading pattern with and without Burnable Absorber rods (BARs). The material compositions and geometry details used are based on FSAR of KKNPP. The k-eff values estimated for initial 60 FAs loading pattern with and without BARs are given in Table 9.1.

Table 9.1: Criticality Estimations for Initial 60 FAs Loading Pattern of KKNPP

S.No	Description	*k-eff*			
		Final	**68% Confidence**	**95% Confidence**	**99% Confidence**
1	Core with initial 60 FAs flooded with unborated water	0.86589 ± 0.00038	0.86551 to 0.86628	0.86513 to 0.86666	0.86488 to 0.86691
2	Core with initial 60 FAs flooded with unborated water (Without BARs)	0.92488 ± 0.00038	0.92449 to 0.92526	0.92411 to 0.92564	0.92386 to 0.92589

(b) Physics Analyses of Metal Fuelled Fast Reactors

It is well established that metal-fuelled fast breeder reactors (MFBR) will be introduced in Indian nuclear power program to enhance the fuel-breeding ratio, consequently lowering the reactor doubling time. In this connection, several reactor designs with varied core composition have been suggested. The MFBR designs being proposed are of 500 MWe and 1000 MWe capacity. The core design of the 500 MWe MFBR is similar to that of the PFBR while the 1000 MWe design is slightly different. The metal fuels considered in the MFBR design are alloys of Uranium-Plutonium-Zirconium with varied concentration of zirconium. The selection of U-Pu-Zr alloy was the fundamental reason for the superior safety characteristics of experimental breeder reactor EBR-II.

In this work, different metal-fuelled cores were analyzed and the reactor physics parameters are compared with that of PFBR. Effect of the number of rows of radial blankets and reactor size on breeding ratio was studied. Normally the zirconium fraction in the metal fuel is 6-10%. However from better breeding consideration, the MFBRs analyzed in this study contain U-Pu-Zr(6%) fuel. Even though some studies are already made on the core neutronic analyses of the MFBRs, the systematic burn up analysis of the same has not been carried out so far. In this study the burnup analysis of a MFBR has also been carried out.

The important finding of this study and future recommendations are the following.

(a) Metal fuelled FBRs offer high breeding ratio which can be around 1.5 for a 1000 MWe design with U-Pu-Zr(6%) fuel and almost the same in case of a 500 MWe design with U-Pu fuel. Even though it is well known that higher Zr content in the fuel alloy gives better structural integrity, it found that by reducing the Zr content the breeding gain improves.

(b) The important safety concern in metal fuelled FBRs is the high positive sodium void worth, which is of the

order of 7 to 8 $. Methods to reduce the higher sodium worth should be worked out in future for ensuring safety in such reactor systems.

(c) It was observed that in the metal core the loss of reactivity with burnup is only half that of the oxide core. Interestingly, the breeding ratio remains nearly constant in metal core, but increases with burnup in oxide core.

(d) The Pu vector is more stable with burnup in metal core compared to that in oxide core. Since multiple fuel recycling is interlinked with FBR growth, this behavior indicates that it is perhaps easier to maintain constant Plutonium isotopic composition (Pu vector) with multiple recycling in metal-fuelled FBR as compared MOX fuelled ones.

(c) Analysis of Neutron Transport Benchmarks by 3-D Transport Method

Three dimensional neutron transport benchmark problems were proposed by Osaka University, Japan for a Nuclear Energy Agency (NEA) Coordinated Research Program (CRP) in 1988. The purpose was to compare the results of the participants to investigate the accuracy of individual 3-D transport calculations and also to setup neutron transport benchmarks to be used for checking the validity of 3-D transport codes. The benchmark problems consist of four core models, three in XYZ geometry and one in hexagonal geometry. The XYZ geometry models consist of a small LWR core, a small FBR core and an axially heterogeneous FBR core while the hexagonal model is a FBR core in hexagonal-Z geometry. To investigate only the differences in the calculational methods, few-group macroscopic cross-sections were supplied for each model instead of the detailed material compositions. Several members from various organizations through out the world had participated in this exercise and have used Monte Carlo method, SN method, spherical harmonics method, nodal transport method and synthesis method for the analyses. In this study, the XYZ transport models are analyzed by the 3-D neutron transport code TRITAC and ATES3 based on discrete ordinate method (SN). The analysis results of the keff, control rod worth and region averaged group fluxes matches very well with the earlier published results in international journals.

(d) Cloud Gamma Dose Distribution from Normal Stack Release

A quick reference table of the cloud gamma dose distribution around a reactor site might be of immense help, while doing preliminary assessment for site clearance. As a first step, computational calculations were carried out to estimate the cloud gamma dose distribution up to a radial distance of 20 km from a fast reactor site during normal radioactive release through a stack. For this analysis, the reactor type considered was 500 MWe PFBR with a stack height of 100 meters. The dose distributions were calculated at different radial distances for normal releases including RCB ventilation system with cover gas purification system (CGPS) not in operation. The computational model adopted for calculations was the standard Gaussian Plum Model. The following assumptions are made to arrive at the results:

Reactor type considered	*Prototype Fast Breeder Reactor (PFBR)*
Stack height	*100 m*
Release type	*Normal releases including RCB ventilation system with cover gas purification system (CGPS) not in operation*
Source term	*Ar-41, Kr-83, Kr-83m, Kr-85, Kr-85m, Kr-87, Kr-88, Xe-133, Xe-133m, Xe-185*
Release rate	*7998.6 Bq/s*
Wind speed	*2 m/s considered*
Stability category	*Pasquill category A and F*
Computational model adopted	*Gaussian plum along with GPM*

The annual site boundary doses at 1.5 km distance range are 8.54E-05 μSv for Unstable (A) and 1.12E-6 for Stable (F) category respectively for the case of normal release without pin failure and no CGPS operation and considering the releases from both CGSP and RCB leak pathways.

(e) Radiation Streaming Experiments

One of the recent activities accomplished by SRI is the optimisation studies on complementary shield structure design with regard to radiation streaming problems associated with PFBR design. As far as the

radiation propagation through the in-homogeneities like ducts and voids present in the shields are concerned, it is very difficult to evaluate and quantify the streaming radiation because the structures are complex and in fact there is no general approach or empirical formulae found suitable for solving all kinds of such problems. Monte Carlo based radiation transport code, MCNP which is applicable for complex configuration of materials is employed to analyses such problems. In order to validate these codes, it is essential to carry out some experimental measurements for typical streaming cases. Towards these objectives, prototype gamma streaming experiments have been carried out at SRI to generate experimental data on gamma streaming. The prototype experimental setup established at SRI for gamma streaming experiments is shown in Fig. 9.1. The isodose contour levels demonstrating the Gamma streaming effects are displayed in Fig. 9.2.

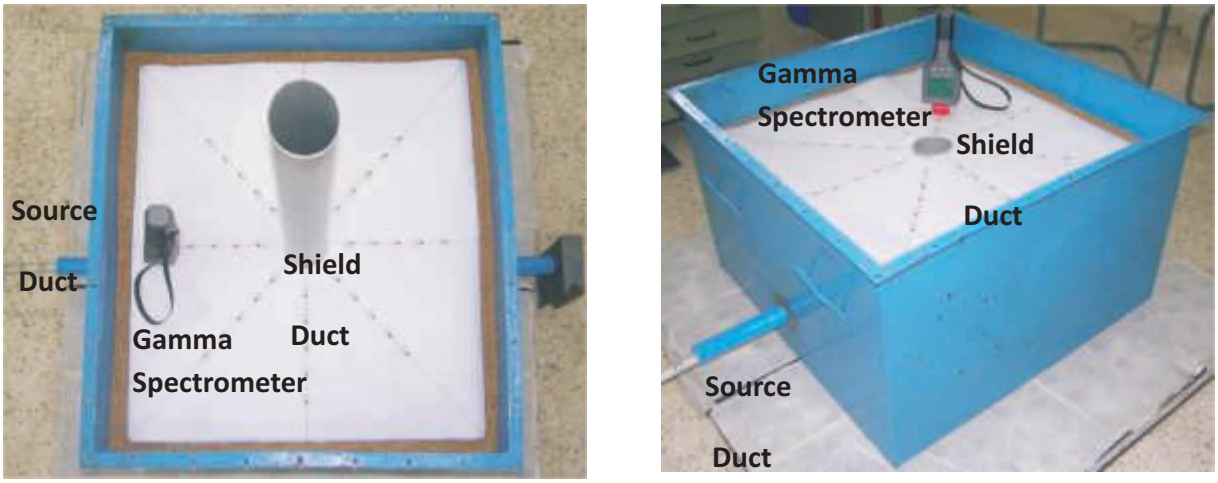


Fig. 9.1: Prototype Gamma Streaming Experimental Setup

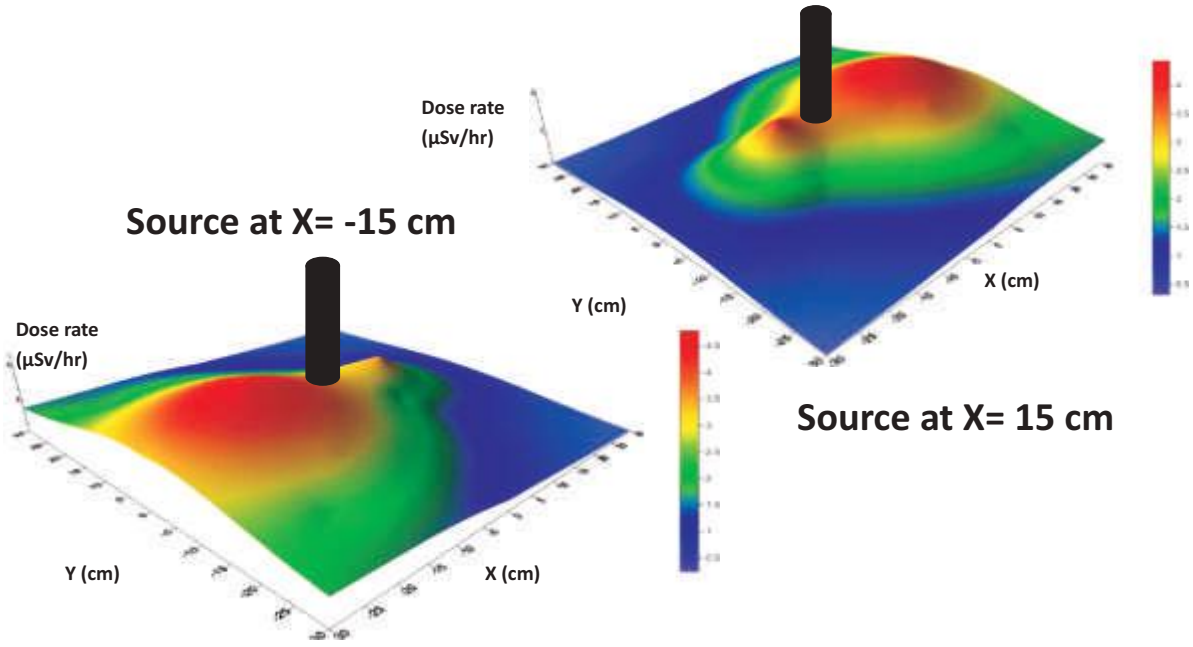


Fig. 9.2: Isodose Contour levels demonstrating Gamma Streaming effects

Preliminary experiments were carried out employing Co-60 gamma source of present activity 0.0718 mCi and digital gamma spectrometer using Ø1.4"x2" NaI (Tl) scintillation detector and an internal GM tube. The data generated through the experiments have been analysed by simulating the experimental set up employing MCNP and IGSHIELD codes. Comparison experimental results with those of computations show very good agreement away from the axis (i.e. in the absence of duct). But, the deviations are observed to be larger up to ~50% in the presence of the in-homogeneities like duct. The present study necessitates further analysis to formulate optimized input parameters for the code in finding solutions for similar radiation streaming problems.

(f) Development of Fission Product Inventory Tool for Fast and Thermal Reactor Fuel Depletion Analysis

Fuel depletion analyses are important to nuclear fuel cycle and management. To carry out studies on isotopic generation and depletion of fast and thermal reactor cores, including spent fuel characterization, a user friendly interface program, ISOGEN has been developed. Like ORIGEN-2, a widely used ORNL point depletion code, the program solves Bateman's equation for the concentrations of isotopes in a material subject to neutron irradiation. The program is developed in VB.NET with a very flexible input scheme that allows user to calculate the burn-up and the fission products fuel inventory for a given reactor power. Further, the code can generate the isotopic history as well as the reactor decay power after the reactor shutdown. The code in its present status can make use of the existing standard libraries of ORIGEN-2 for the necessary nuclear data information like the cross sections, fission product yields, radioactive decay data and photon data during the execution of the code.

In addition to performing depletion calculations, the code is capable of providing other useful information like gamma spectrum emitted by nuclides, list of parent nuclides for a prescribed daughter nuclide, and fission yield curves etc.

(g) Development of Web Based Utility Programs for Radiological Physics Data and Radiation Shielding Calculations

Knowledge on radiation sources/ fields and their permissible concentrations/ strengths is essential for carrying out regulatory inspections. For instance, while inspecting fuel reprocessing facility, the regulatory inspector must know or must have quick access to information on the possible nature of sources and their derived concentrations in air and water. Further, radioactive gases and their discharge limits through stack also to be remembered. To get information on essential things in easy accessible way is through the Intranet route. Therefore, SRI has taken up to develop an intranet site not only to provide information on radiological data but also ability to do some simple shielding calculations.

9.1.2 Reliability and Probabilistic Safety Assessment

(a) Probabilistic Approach for Seismic Capacity Assessment of Fast Breeder Test Reactor (FBTR)

Seismic re-evaluation of FBTR was carried out to review the extent of seismic excitation that the reactor and associated systems can withstand without compromising the desired level of safety. It is evaluated by assessing seismic capacity of structures, systems and components required for the safety functions. The evaluation was carried out by both deterministic approach called seismic margin assessment and probabilistic approach called seismic probabilistic safety assessment (SPSA). During the period of this report, SPSA was carried out and the salient features of SPSA include detailed analysis of common cause failures (CCF) and human actions. Since redundancies cannot be credited during a seismic event, CCF modeling is done by grouping redundant components such as circuit breakers, relays, steam generator trap doors, etc. located at the same elevation. Human actions were categorized based on the time available for safety action during an earthquake.

(b) Combination of Category-2 Events of Prototype Fast Breeder Reactor (PFBR)

A study on identifying credible combination of category-2 events of PFBR was carried out. The aim of this study was to generate realistic estimates of combined event frequency by examining interdependency and sub-system analysis. The qualitative study was carried out by grouping the category-2 events based on consequences. The combinations of most frequent events are analyzed and ranked based on the likelihood of failure of decay heat removal.

(c) Application of Hazard Operability (HAZOP) of Fuel Cycle Facilities

Application of HAZOP for head end cycle of fuel reprocessing plant (FRP) of fast reactor fuel cycle facilities

(FRFCF) at Kalpakkam was carried out. The aim of this study was to identify and evaluate the potential hazards by analyzing the processes carried out at various stages of the process cycle, the chemicals used, the equipment involved, the conditions adopted for the process and safety devices/interlocks provided. Based on the analysis, few recommendations pertaining to the head end cycle of the fuel reprocessing plant are made from the safety vewpoint. Although a standard practice exists for conducting HAZOP in industries, it is the first time that HAZOP is applied to a nuclear fuel reprocessing plant.

(d) Mutation Technique to Estimate Software Reliability

After several years of research, even today estimation of software reliability is extremely challenging. The non-deterministic nature of the factors that contribute to the reliability estimation has led to the development of numerous statistical models for this purpose. Fault injection or mutation testing technique to find 'the true' reliability of a system was studied. Using this technique, a framework to create a software failure dataset, which could be used to find the uncertainty bounds associated with testing and for measurement of different factors that influence uncertainty in reliability estimation, such as test coverage, time between failures and code coverage is proposed. The approach is experimented with an open source search tool.

(e) Analysis of Simulation Techniques for Passive Decay Heat Removal System Reliability

Passive systems, which completely depend on natural phenomena such as gravity, conduction and convection to accomplish the safety functions, are increasingly being used in new generation nuclear reactor designs. However, since the driving forces of passive systems are weak, they are more vulnerable to associated uncertainties and there may be a non-zero probability for the system to deviate from the intended behavior and lead to functional failure.

Methods for quantification of the functional failure include Monte-Carlo simulation of the system uncertainties using a validated mechanistic code. Generally, the mechanistic codes used for complex system modeling are computationally expensive and Monte-Carlo simulation for estimating small failure probabilities requires more time and often become prohibitive. Existing functional reliability methodologies are enhanced using advanced Monte Carlo simulation techniques such as subset simulation, response surfaces, Markov chain Monte Carlo and response conditioning method to obtain computationally efficient as well as consistent reliability estimates. The efficiency and consistency of these simulation methods are studied through a case study. The advantages and disadvantages of each technique are comprehended.

(f) LAN Based System for Radiological Survey Measurement

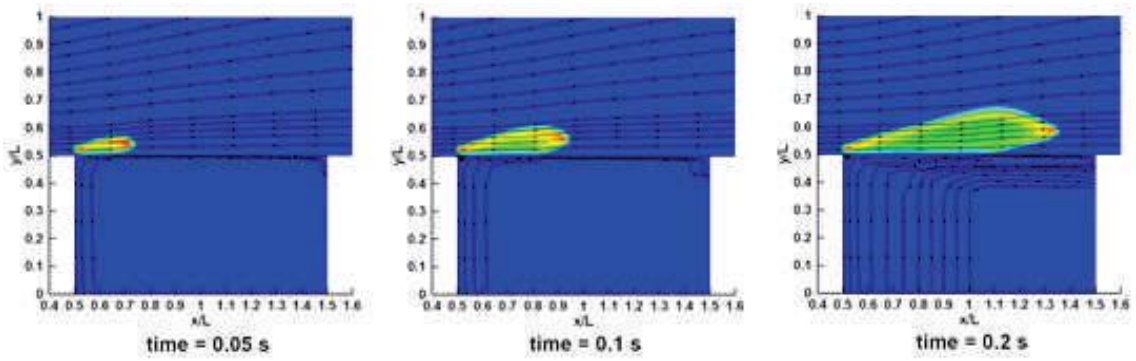
Embedded software is developed to acquire online environmental radiation monitoring data from the radiological gamma dose survey instrument installed at remote locations around the nuclear facilities at Kalpakkam and communicate the real-time data to a server through a local area network. A graphical user interface provides a real-time comparison of gamma dose rate in all such locations, which can be used for the assessment of dose and when coupled with real-time meteorological conditions it could predict the plume behavior of radioactive dose to the public during untoward incidents. The system can also be used to monitor the source movements around the site.

9.2 ENGINEERING SAFETY STUDIES

9.2.1 Fire Safety Studies

(a) Theoretical Studies

A transient, multiphase combustion code based on the Finite Volume method is developed from the fundamental principles to address flame/fire-spread process on fuel pool surfaces. The physics involved in transient flame spread is captured in a multi-phase model, by coupling the gas and liquid phases using appropriate interfacial boundary conditions. The capability of this transient model is assessed by means of a case study involving concurrent flow flame spread on methanol fuel pool, 40 cm long, 2 cm deep and of infinite width. The fuel is ignited at the leading edge at a height of approximately 0.05 cm from its surface. Fig. 9.3 shows the flame propagation by means of temperature contours and streamlines at three instants i.e., t=0.05 s, 0.1 s and 0.2 s. The average flame speed is found to be approximately 1.68 m/s, which is in good agreement with the experimental value of 1.76 m/s obtained for similar conditions.

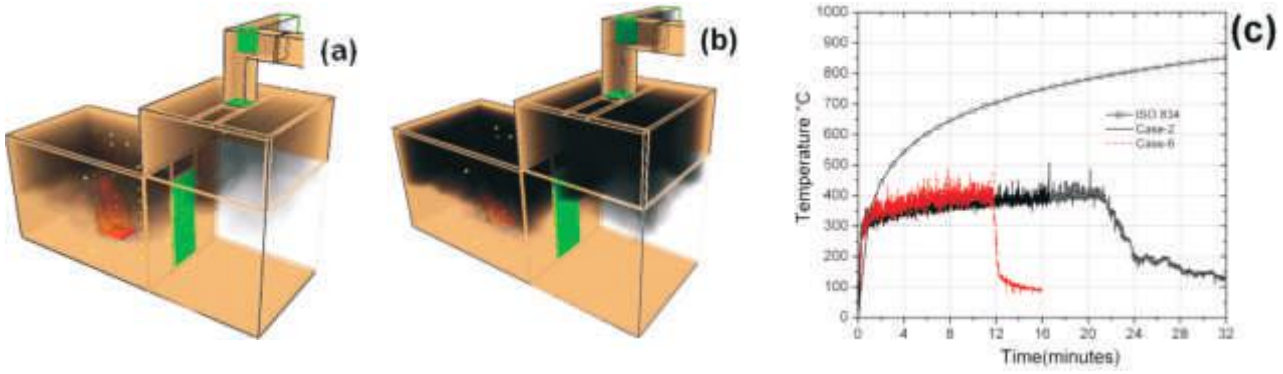


Computational domain: Gas phase 48 cm × 48 cm; Liquid phase 40 cm × 2 cm; ignition source size:0.10 cm × 0.05; u_∞=1.3 m/s (Flow direction: Left to right)

Fig. 9.3: Flame Propagation on Fuel Pool Surface

(b) Experimental Program

As part of thermal design of the proposed compartment fire test facility, the limiting fire size (Design Basis Fire) and its duration are estimated. To achieve our objective, several pool fire scenarios involving various quantities liquid fuels/combustible solvents are simulated. Figs. 9.4(a) and (b) show snapshots of the design basis fires for two fuels. Fig 9.4(c) shows the comparison of hot gas temperature transients with ISO 834 fire curve. The fire resistance rating of the test facility and its exhaust system design are based on these design fire conditions.



(a) Snapshot of 28 kg ethanol fire (4% floor area, case 2)
(b) Snapshot of 7 kg kerosene fire (1% floor area, case 6)
(c) Temperature Vs. time curve

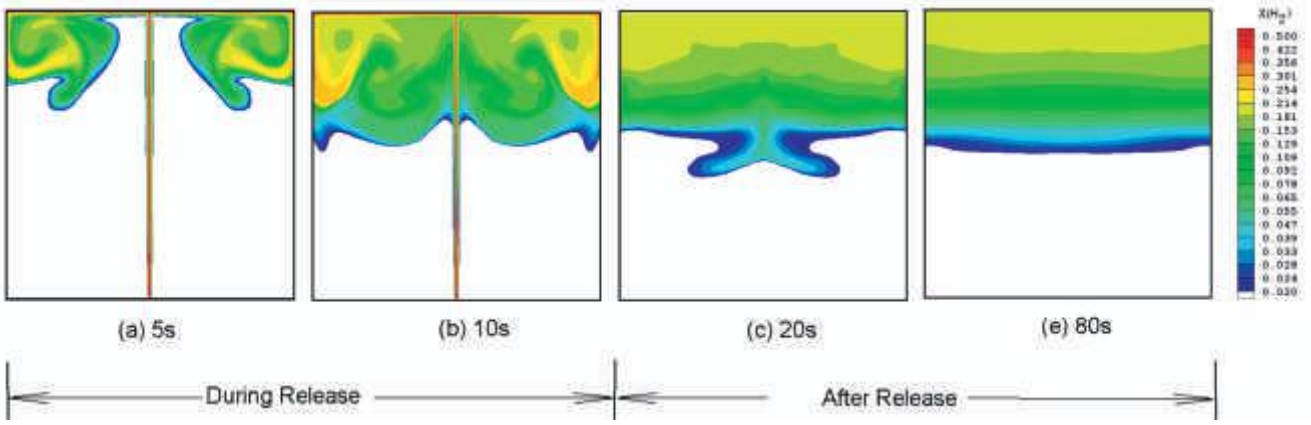
Fig. 9.4: Comparison of Hot Gas Temperature Transients

9.2.2 Thermal Hydraulic Studies

(a) Hydrogen Distribution in Enclosures

A finite volume based CFD code Hydrogen Distribution Simulator (HDS) is under development at SRI. The code was validated for is now being used for hydrogen distribution studies in enclosures. Studies have been carried out to address the following phenomena (a) Dispersion of a stratified layer of hydrogen-air mixture due to diffusion; (b) Influence of natural convection on the dispersion of stratified layer of hydrogen (c) Release of hydrogen as jet in enclosures. These studies are meant to study the separate and integral effect of various phenomena that influence hydrogen distribution.

One such study, related to hydrogen release as a buoyant jet is shown in Fig.9.5. The figure shows the contour plot of hydrogen mole fraction during release phase and sometime after the release phase. From this study, it was concluded that in the initial stages, jet dynamics influences the mixing process and in the later stages molecular diffusion alone is responsible for the mixing process.

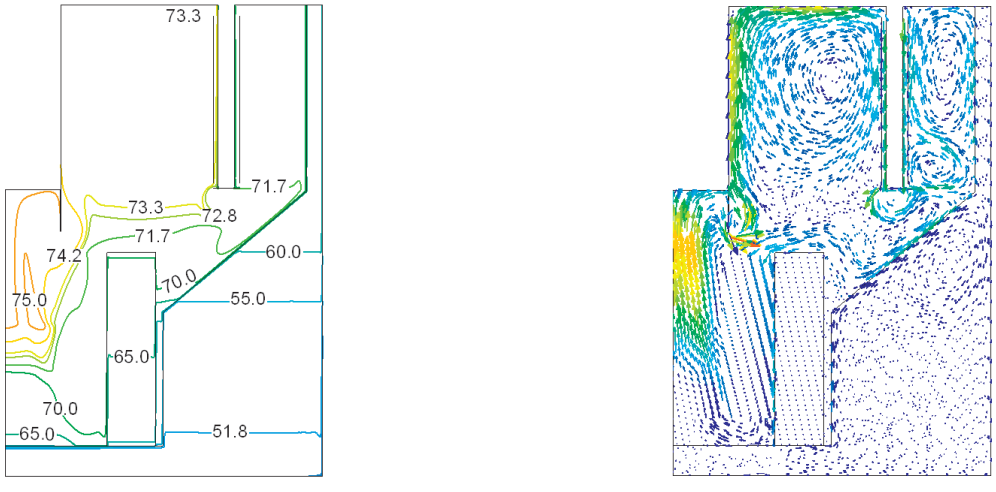


Computational domain: 2 m × 2 m ; jet width: 2cm; Release rate: 2.9g/s (injection velocity: 1.6m/s)

Fig. 9.5: Contour plot of Hydrogen mole fraction for release at Fr value of 1.

(b) Numerical Analysis of Decay Heat Removal System

Numerical modeling of the natural circulation phenomena occurring in the Safety Grade Decay Heat Removal System (SGDHRS) of Prototype Fast Breeder Reactor (PFBR) is being carried out in a joint exercise between SRI and IGCAR. A commercial CFD code is being used for the purpose. Two-dimensional axi-symmetric model with porous media approximation for the core is used for the present analysis. Two different turbulence models (Standard k-ε and Shear Stress Transport k-ω models) are used to assess their capability to predict the natural circulation phenomena. A clear thermal stratification between the core outlet and Decay Heat Exchanger (DHX) outlet was predicted by the SST k-ω model; standard k-ε model failed to reproduce complete thermal stratification. These studies have demonstrated the effectiveness and superiority of SST k-ω model over the standard k-ε model. Fig. 9.6 (a) shows the temperature contour plots for the SST k-ω model case. The flow through the walls of the above-core-structure and free surface can be identified from the velocity vector plot (Fig. 9.6 (b)). The results obtained are within ±15% of the experimental results.



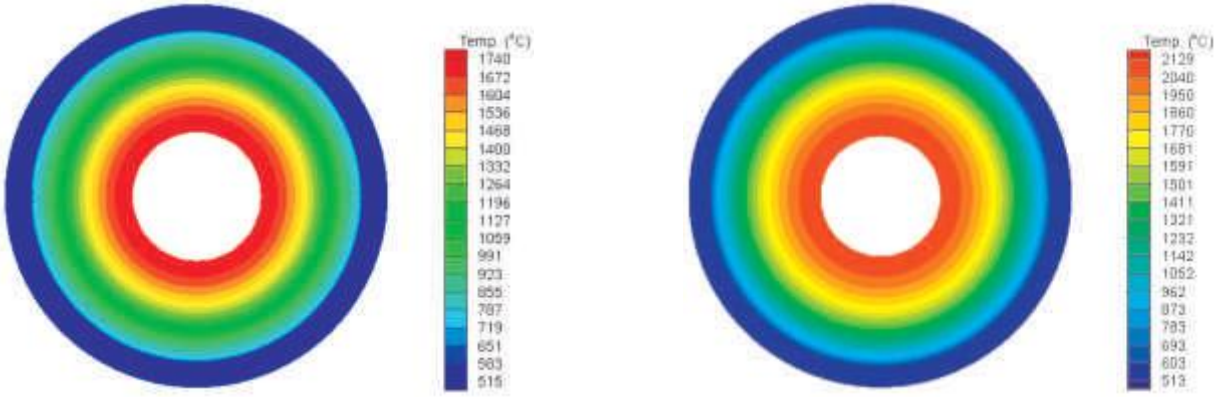
(a) Temperature (°C) contours for SST k-ω Model (b) Velocity Vectors for SST k- ω Model

Fig. 9.6: Velocity Vector Plot

(c) PFBR Fuel Performance Analysis

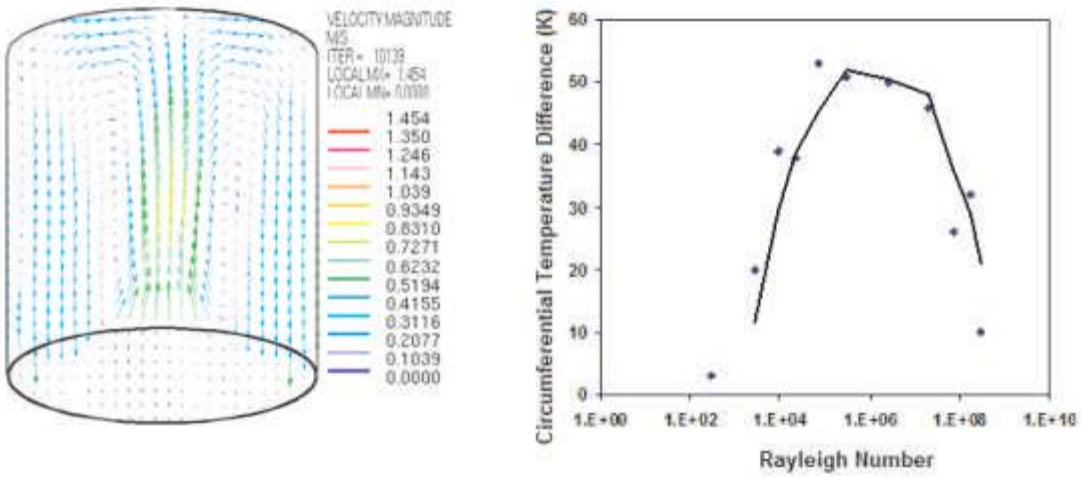
The fuel selected for PFBR is Mixed Oxide (MOX) and the clad material is D9. A targeted peak linear power and a peak burn up (BU) are 450 W/cm and 100 GWd/t respectively. For safe operation and at the same time to achieve higher BU without any fuel pin failure, it is of utmost importance to correctly estimate the variation of various parameters with BU, namely the variation of centerline temperature, fission gas pressure, FCMI (Fuel Clad Mechanical Interaction) pressure, clad wastage due to Fuel Clad Chemical Interaction (FCCI) and Na corrosion & erosion, stresses in the clad, Cumulative Damage Fraction (CDF) incurred in the clad for the envisaged BU.

A computer code (SATURN-FS1) for thermo-mechanical analysis of fuel rod is used for the analysis of peak rated fuel pin which was modified for taking into account the effect of axial power profile, D9 material properties, updated MOX fuel properties, FCCI. Suitable numerical integration is adopted for the calculation of primary membrane & bending stresses in the clad. Fig. 9.7 shows the temperature distribution across fuel pin at BOL (Beginning of Life) and EOL (End of Life). It was observed that from fuel performance point of view there is still sufficient margin to go for higher burn up.



(a) (b)

Fig. 9.7: Temperature Distribution Across Fuel Pin (a) BOL; (b) EOL



(a) (b)

(a) Velocity field for cellular convection (b) Variation of circumferential temperature difference with gap width

Fig. 9.8: Cellular Convection in Fast Reactors

(d) Cellular Convection in Roof Slab Penetration of Fast Reactors

The top shield of a typical pool type fast reactor has several penetrations for components like pumps and intermediate heat exchangers. Cellular convection in the narrow vertical annular gaps, formed between the roof slab and these components, is not axis-symmetric in some cases. The non-uniform circumferential temperature distribution leads to deflection in the components and stress due to interference with other reactor components. Three-dimensional computational fluid dynamic investigations have shown that cellular convection is highly sensitive to process and geometric parameters. For typical temperature and cooling conditions, no convection occurs for modified Rayleigh numbers up to 300 (i.e., gap width of annulus < 5 mm). For certain range of Rayleigh numbers, 2500-3x10^8 (i.e., gap width of annulus 10 mm – 500 mm) cellular convection takes place in the annuli (Fig. 9.8 a). When the Rayleigh number exceeds 3x10^8, the cellular convection is seen to break down as indicated by decrease in circumferential temperature difference (Fig. 9.8 b). Increase in cooling airside heat transfer coefficient results in more number of convective loops which decreases the circumferential temperature difference in structures and vice versa.

9.2.3 Structural and Seismic Analysis

(a) Reliability Estimation of Components using iHOSRSM

A procedure based on improved high order stochastic response surface method (iHOSRSM) is developed for the estimation of reliability of components. The procedure first accurately estimates the order of the Chebyshev polynomial and subsequently estimates the significant mixed order terms required for Limit State (LS) approximation. To save computational effort, the significant mixed order terms are checked as per their numerical significance and their contribution to adjusted R^2 of the regression model. The selection of Chebyshev polynomial as basis function for order estimation as well as LS estimation eliminates the need for LS evaluation required for terms with single variables in approximate polynomial.

Six numerical examples taken from literature, enveloping diverse engineering areas, are evaluated using the iHOSRSM. All the results are validated with those obtained from Monte Carlo Method. Furthermore, iHOSRSM has significant computational advantage over other established methods like second order HDMR or eHDMR.

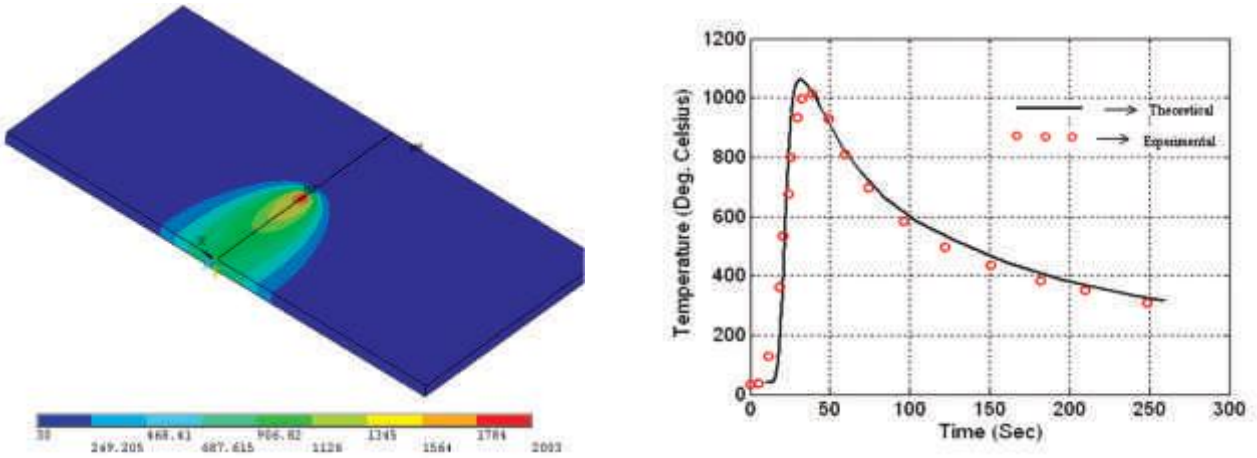
(b) Thermal Transient Analysis of Welded Joints of AHX Tubes of PFBR

A procedure for transient thermal analysis for weld joints is developed using the commercial software ANSYS. The numerical model effectively accounts temperature dependent material properties, solidification of weld metal as well as the boundary conditions necessary for convective and radiative modes of heat transfer. The various welding passes in the weld joints are simulated using 'birth' and 'death' cell features (Fig.9.9). The theoretically estimated results are validated against the experimental values. The validated procedure is then used for the estimation of temperature distribution in weld joints of AHX tubes. The transient temperature distribution will be used for residual stress estimation in the welded joints and its effect on the failure behavior of the AHX tubes.

9.2.4 Reactor Structural Material Testing and its Characterization

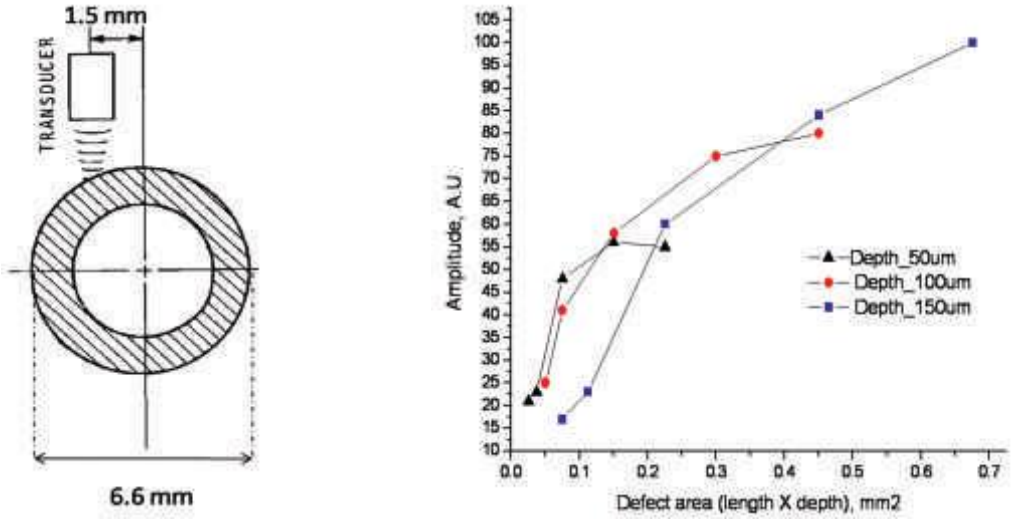
(a) Development of Ultrasonic Inspection Method for PFBR Fuel Clad Tube

An ultrasonic guided wave based methodology has been developed to detect defects in PFBR clad tubes made of cold worked alloy D9 (Ti-modified 316 austenitic stainless steel), having thickness of 0.45 mm and the outer diameter of 6.6 mm. Defects of the order of 0.5mm (L) × 0.2mm (W) × 0.05mm (D) (10% wall thickness) can be detected in PFBR fuel clad tubes. For the inspection of clad tube, a beam is made to incident at a suitable angle to the tube surface and is allowed to refract as a guided wave into the tube wall. Any discontinuities in the path of the beam will return energy along the incident path. To realize this, a focused immersion ultrasonic transducer of suitable frequency focuses a beam on the surface of the tube. The wavelength is chosen to be equal to the thickness of the clad tube to generate ultrasonic guided waves. The distance between the ultrasonic probe to the center of the tube controls the angle of incidence of the ultrasound beam at the tube surface; the refraction and the reflection of the beam in the tube was optimized subsequently. Fig. 9.10 (a) shows the inspection arrangement for the tube. In order to establish an inspection procedure, reference defects with different lengths and different depths were made parallel to axial direction on the outer surface of the fuel clad tubes. Fig. 9.10 (b) shows the amplitude response of defects obtained by the above procedure for inspection.



(a) Temperature profile during welding of plate (b) Temperature profile at 11.0 mm from weld joints

Fig. 9.9: Thermal Transient Analysis of Welded Joints



(a) Inspection arrangement of tube and probe; (b) Amplitude response of defect with different depth and length

Fig. 9.10: Ultrasonic Inspection Method of PFBR Fuel Clad Tube

(b) Tensile Flow and Work-hardening Behaviour of P9 Steel

9% Cr ferritic-martensitic steels are being considered as the in-core structural material in view of their resistance to irradiation-induced void swelling and good high temperature mechanical properties. ASME and RCC-MR codes don't govern the design of in-core structural components for FBR, therefore, development of material database for design and structural integrity analysis is essential. In order to develop a good database on mechanical properties of P9, tensile testing was carried out over the range of temperature (300–873 K) with different silicon contents (0.24 %, 0.42%, and 0.60%). Tensile flow and work hardening behavior of wrapper steel are analyzed through different constitutive equations such as such as Hollomon, Ludwik, Swift, Ludwigson and Voce. The mechanism for plastic instability is investigated in terms of parameters obtained from constitutive relations. A rapid decrease of tensile parameters was found to occur above 723 K. It was also found that the variations of silicon content were insignificant role on tensile properties.

9.2.5 Reactor Neutronics and Instrumentation Studies

Estimation of Neutron Flux by Principal Component Analysis (PCA) Method

Neutron flux in fast reactor varies over 10 decades from shutdown to full power. This is monitored for all states of the reactor by neutron flux monitoring systems. The system consists of several sets of detectors and instrument channels. For smooth transition from one set of instrument channel to other, interlocks with auto inhibition in safety logic are provided. It is known that as the frequency goes up, the pulses over lap. Hence, estimating the power using pulse counting cannot predict the power correctly. Hence, the new approach viz. PCA (Principle Component Analysis) is developed.

PCA is non-parametric method of extracting relevant information from mixed data by reducing a complex dataset to a lower dimension to reveal the hidden, simplified dynamics that often underlie it. This innovative method can be applied for the design of miniature state of the art neutronic channels for future FBR.

9.3 ENVIRONMENTAL SAFETY STUDIES

9.3.1 RS-GIS Studies

(a) GIS Database Generation for Uranium Mine, Mill and Tailing Pond Area of Turamdih

A geo spatial database was generated for Turamdih tailings pond area on drainages, lineaments, surface water bodies, lithology, soil, land use/ land cover, Digital Elevation Model (DEM) and hydro-geomorphology (Fig. 9.11 a). From this study it was observed that the tailings ponds are located in a massive Granophyre rock type of Archaean age, pediplain (moderate depth) category of hydro-geomorphology and in an area devoid of major fractures. It was also found that there are no major surface water bodies in the vicinity of the tailings pond area.

(b) Remote Sensing and GIS based Environmental Assessment for Tummalapalle Uranium Mines (50 km Radius), Cuddapah, Andhra Pradesh

The environmental assessment of uranium mining/milling operations at Tummalapalle, Andhra Pradesh was studied by employing RS-GIS techniques. The spatial maps for 50km radius from Tumalapalle mine on lithology/geology (Fig. 9.11 b), soil, surface water bodies and drainage network were generated to evaluate various environmental scenarios with regard to location of mining/milling facilities, delineate possible flow paths to nearby water bodies from tailing ponds, assessment of spatial radioactive levels near the mining/milling facility.

(c) Generation of Remote Sensing and GIS Based Inputs of Kalpakkam Site for Round Robin Exercise on Atmospheric Flow Field Modeling

A comprehensive geo spatial database on DEM, soil and land use/ land cover were generated for three spatial domains 120km, 10km and 2 km area, in the required format specified by the committee on Round Robin Exercise on Atmospheric Flow Field Simulation and Validation to share with the participants.

(d) Spatial mapping of Sea Surface Temperature with respect to MAPS Condenser Coolant Discharges using RS – GIS

Studies on prediction of sea surface temperature (SST) at MAPS condenser coolant discharge area using remote sensing data were attempted. The study aims to derive temporal characteristics of thermal plume using satellite derived Thermal Infra Red (TIR) images. Studies include processing and conversion of Satellite data obtained from USGS website into SST by employing suitable algorithms. The preliminary results are very satisfactory. Further validation efforts are underway to evolve an algorithm to estimate SST of thermal discharges from the satellite derived data.

(e) RS-GIS based Decision Support System during Flood Hazard

(1) Decision support Studies for Flood Hazard

The Analytic Hierarchy Process (AHP), a Multi Criteria Decision Analysis (MCDA) approach was attempted to delineate flood zones at Kalpakkam plant site by generation of elevation, aspect and land use maps. These maps were prepared using ArcGIS 9.3 software. Site-specific criteria weights for Kalpakkam site viz., 0.68, 0.19 and 0.13 for elevation, aspect and landuse parameters were arrived based on the pair-wise comparison matrix generated using relative importance of the parameters. The composite vulnerability map was generated for the study area from the vulnerability index derived for each pixel for a hypothetical flood hazard.

(2) Mapping of Green cover and land use Characteristics for Kalpakkam site

The mapping of green cover and land use

characteristics for Kalpakkam site was attempted in collaboration with E&ISS, IGCAR. This mapping work was carried out for the years 2006 to 2010. The green cover NDVI maps were generated using available Landsat ETM+ satellite images (30 m resolution) for wet season and dry seasons.

Validation of results based on user expertise and/or ground truth verification as well as the computation of accuracy using the spatial statistics techniques were completed. The total accuracy for present study is calculated as 90% using GIS based accuracy assessment techniques.

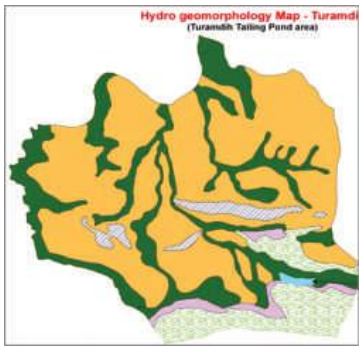
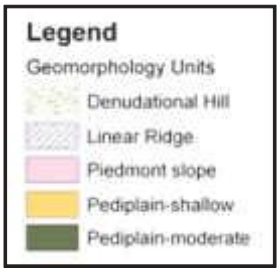


Fig. a: Hydro-geomorphology of Turamdih area



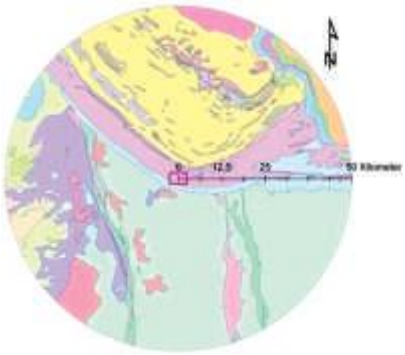


Fig. b: Lithology/geology map of Tummalapalle area (50 km radius)

Fig. 9.11: RS-GIS of Turamdih area and Tummalapalle Mine

9.3.2. Hydrogeological Investigations at Kalpakkam

(a) Sensitivity Analysis-Groundwater Modeling

A 2-layer aquifer model for Kalpakkam plant site was developed using the Visual MODFLOW Pro Ver.2009.1. The monthly groundwater head was recorded for 26 bore wells. The sensitivity analysis was carried out for four variables namely hydraulic conductivity, specific yield, specific storage, and boundary conditions. It was observed that hydraulic conductivity was the most sensitive parameter. The other sensitive parameters included specified head boundary and recharge boundary conditions.

(b) Round Robin Exercise (RRE) on Groundwater Flow and Contaminant Transport Modeling

As a part of BRNS Round Robin Exercise (RRE), a test case was solved using Visual MODFLOW version 2009.1. The test case-2 problem involves numerical modeling of three-dimensional groundwater flow and contaminant transport for an unconfined aquifer having homogeneous and isotropic properties. The 23 model outputs were generated and the results obtained matched well with analytical results as well as with other RRE participants. A typical contaminant plume in x-y plane after 60 years shown in Fig. 9.12.

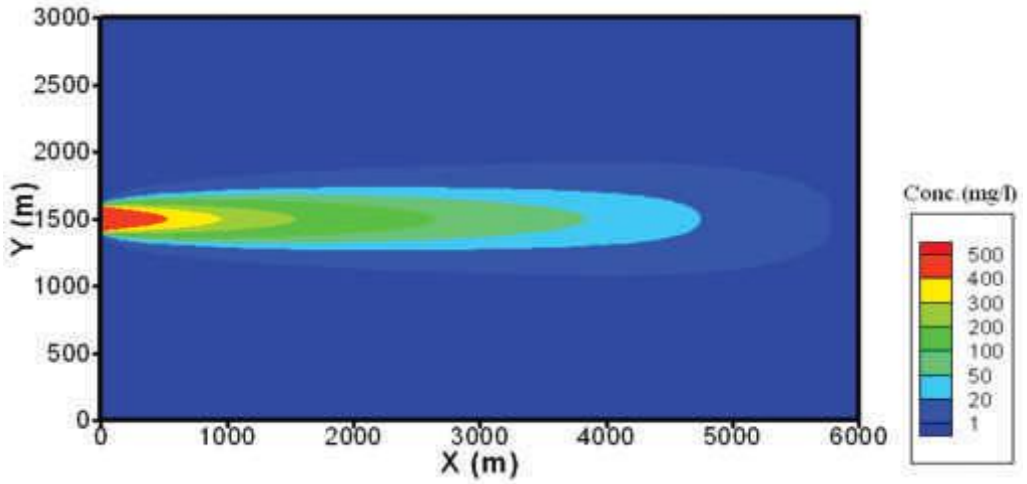


Fig. 9.12: Two-dimensional plot of contaminant plume in the x-y plane after 60 years

9.3.3 Geochemical Characterization and Modeling of Kalpakkam Site

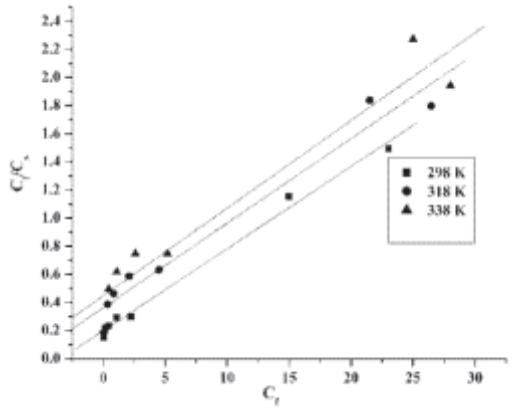
Based on the groundwater characterization using chemical analysis, various geochemical processes of Kalpakkam site were deduced. By using the saturation index approach, it is possible to predict the reactive mineralogy of the subsurface from groundwater data without collecting the samples of the solid phase and analyzing the mineralogy. Studies were carried out for the determination of disequilibrium indices log (IAP/KT) by geochemical software, PHREEQC. Saturation Index (SI) = log (IAP/Ks) where IAP is the ion activity product and Ks is the solubility product of the mineral. Various minerals present at Kalpakkam site such as Calcite, Aragonite, Dolomite, Gypsum, Anhydrite, hydroxyapatite and fluorite were determined every month from the ground water characterization

PHREEQC data shows that the minerals that tend to precipitate in the groundwater follow the order Dolomite > Calcite > Aragonite. Interpretation of hydrogeochemical data suggested that calcium carbonate dissolution, ion-exchange processes, evaporation and sea water incursion were responsible for the groundwater chemistry of the study area.

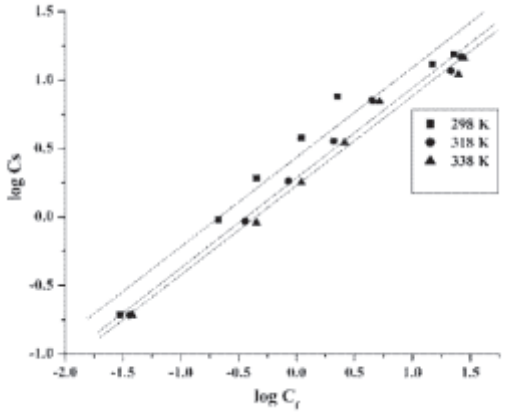
9.3.4 Waste Management Related Studies

(a) Role of Colloids in the Transport of Radionuclides in Groundwater

Sorption of radionuclides onto stable colloids can significantly enhance their transport in groundwater. Batch adsorption studies were performed to evaluate the influence of various experimental parameters like initial pH, temperature and concentration of Na+ and Ca_2+ ions on the sorption of Cs on clay. The sorption process was found to be dependent on pH and distribution coefficient (Kd) found to increase with increase in pH. The thermodynamic parameters such as ΔG_0, ΔH_0 and ΔS_0 were calculated (Figs. 9.13 (a) & 9.13 (b)).



(a) Langmuir isotherm plot for the sorption of cesium on clay colloid



(b) Freundlich isotherm plot for the sorption of cesium on clay colloid

Fig. 9.13: Isotherm Plot for Sorption of Cesium

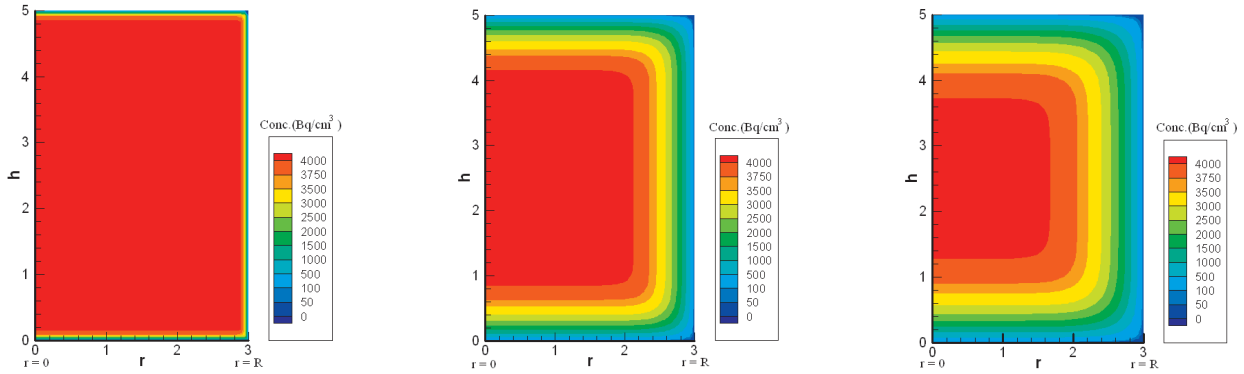
The negative value obtained for ΔH_0 indicates that the reaction is exothermic. The negative values obtained for ΔG_0 indicated that the sorption of cesium on clay was spontaneous at all studied concentrations. The distribution coefficient was found to decrease with increase in concentration of Na+ and Ca_2+ ions. The cesium sorption data was fitted to different sorption isotherms namely the Freundlich, Langmuir, Temkin and Dubinin–Radushkevich (D–R) isotherms. The values of Langmuir separation factor (R_L) indicate a favorable Cs adsorption. The values of mean free energy of sorption (E) at various temperatures ranged from 10.5 to 11.1 kJ/mol. This corroborated that the sorption process follows chemisorption.

(b) Development of Diffusion Release Model for the Release of Radionuclides from the Waste Matrix

Low and intermediate wastes generated from various nuclear installations are disposed of in Near Surface Disposal Facilities (NSDF's). The radionuclides are immobilized in solid matrices before placing it in metal containers, which in turn buried in various near surface disposal modules depending upon its activity levels. Under adverse circumstances these barriers can fail, allowing the infiltrating rainwater to come in contact with the bare waste form. Once water comes in contact with the waste form radionuclides can be leached out into the surrounding

media by various processes. When wastes are immobilized in porous medium such as cement, diffusive control of leaching is normally assumed. Leach rates of various radionuclides from solidified wastes into contacting groundwater, constitute the source term to radionuclide hydrogeological transport models.

In the present study, the cylindrical diffusion equation was solved numerically for Cs-137 concentration by using finite difference method. Since the cylindrical waste form is symmetrical with respect to the central axis, the distribution of Cs-137 concentrations in one half of the waste form is shown in Fig. 9.14 at various time periods 0,100 and 200 days. Radionuclide leach rates from the waste form were also estimated for a period of 200 days.



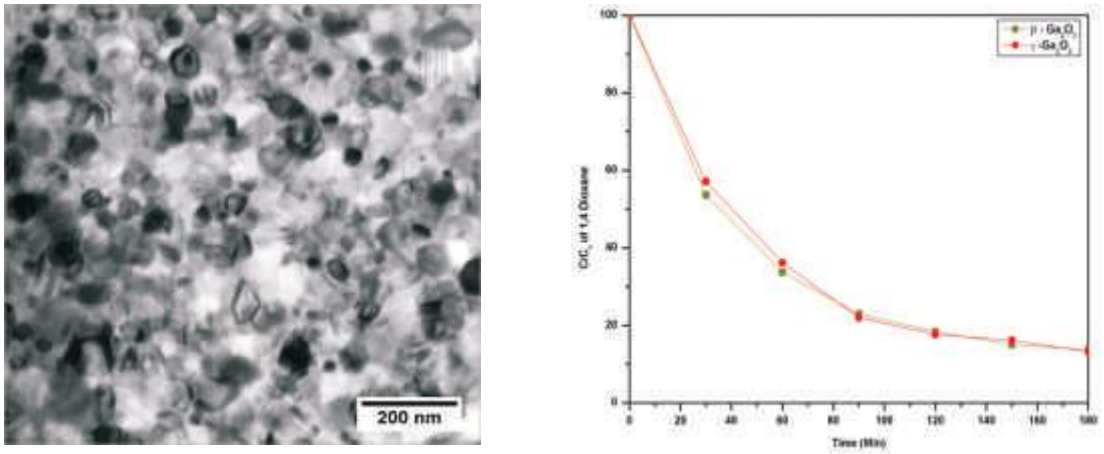
Two-dimensional plot of Cs137 concentrations in one half of the waste form at various time periods 1 day, 100 days and 200 days

Fig. 9.14: 2-D Plot of Cs-137 Concentrations

(c) Application of Nanotechnology for Waste Treatment Applications

Degradation of organic effluents is a challenging task due to their properties such as non bio-degradability, toxicity etc. Photocatalytic degradation using semiconductor photocatalysts is an advanced oxidation process that follows green chemistry route without the formation of toxic intermediates.

Two nano-sized semiconductor photocatalysts, - and -gallium oxide were synthesized at SRI laboratory using solution combustion route. Pure Gallium metal was taken as the starting material and urea was used as the fuel. The synthesized catalysts were characterized using powder XRD, SEM, TEM, BET, FTIR, DRS, TG-DTA and Raman Spectroscopy (Fig. 9.15 a). The characterization confirmed the nano size of the catalysts and thus their suitability as a catalyst for photocatalytic application.



(a) TEM image of β-Ga_2O_3

(b) Kinetics of 1,4 Dioxane degradation using β-&γ-Ga_2O_3

Fig. 9.15: TEM Image

Photocatalytic degradation of few organic effluents such as 1,4 dioxane and Nitrilotriacetic acid was successfully studied using the synthesized polymorphs of gallium oxide. 10mg of nano sized catalysts were used for the degradation of 1000ppm of 1,4 dioxane. More than 95% of 1,4, dioxane degradation has been achieved in less than 120 minutes using both beta and gamma gallia indicating the robustness of the method (Fig. 9.15 b). For the degradation studies of Nitrilotriacetic acid (NTA), 1000ppm of NTA was taken and 10mg of the photocatalysts were employed. More than 85% of NTA degradation has been achieved in less than 150 minutes.

CHAPTER 10

PUBLIC INFORMATION

10.1 PRESS RELEASES

AERB periodically issues press releases in English and Hindi to keep the public informed about important regulatory and other related activities. During this year, twelve press releases were issued and the details on the same are available in AERB Website.

i. Incident of radioactive material discovered in scrap dealers shops in New Delhi issued on April 10, 2010

ii. Incidents of radioactive material discovered in scrap dealers shops in New Delhi issued on April 16, 2010

iii. AERB Industrial and Fire Safety Awards issued on April 20, 2010

iv. Incidents of radioactive material discovered in scrap dealers shops in New Delhi issued on April 29, 2010

v. Incident of radioactive material discovered in scrap dealers shops in New Delhi issued on May 05, 2010

vi. Incident of radioactive material discovered in scrap dealers shops in New Delhi issued on May 18, 2010

vii. New Secretary for AERB issued on August 02, 2010

viii. French delegation visits Atomic Energy Regulatory Board issued on November 23, 2010

ix. Agreement between AERB – ASN and AERB – IRSN issued on December 07, 2010

x. AERB permits use of low strength radiation sources by Delhi University issued on January 25, 2011

xi. AERB reviews safety in Indian nuclear power plants issued on March 15, 2011

xii. No radiological impact in India from Japan incident issued on March 17, 2011

xiii. Actions taken by AERB post Fukushima incident issued on March 28, 2011

10.2 AERB NEWSLETTER

AERB Newsletter covers AERB press releases, important national and international news, safety reviews of plants / projects and authorizations issued to nuclear and radiation facilities, activities related to training, workshops, colloquia, seminars, symposiums, etc., The Newsletter also carries expert views regarding safety of nuclear and radiation facilities. AERB Newsletters Vol. 23 No.1 and 2 covering the period from January to June, 2010 and July to December 2010 were published in English and Hindi during 2010-11.

10.3 ANNUAL REPORT

Annual Report of AERB brings out the details of work carried out in various divisions of AERB during every financial year for fulfilling the mandate. The report is widely circulated to all the units and Public Sector Undertakings under the DAE, Nuclear Regulatory Agencies of other countries, IAEA, premier educational and research institutes in India, Radiological Safety Officers of various hospitals and nuclear installations, news agencies in India, ex-members and Chairmen of AERB, Ex-Directors and Ex-Heads of the divisions of AERB. The report is published in English as well as in Hindi.

10.4 WEBSITE MANAGEMENT

AERB as part of its policy of public information has been posting information relevant to public and licensees on its website. The information related to use of radiation in medicine, industry and research for societal benefits and beach sand mineral industries has also been put on the website. The information includes the applicable acts, codes and rules, regulatory and safety documents and regulatory application forms related to issuance of licenses, authorizations and registration etc. New forms for radiation facilities were uploaded. About 6 lakh hits to the website were reported during this period.

10.5 INTERACTION WITH MEDIA

Queries raised by media are replied by phone and e-mails as well as during press meets by the senior officers of AERB.

10.6 RIGHT TO INFORMATION ACT-2005

Required measures were taken on the implementation of 'Right to Information Act (RTI)' in AERB and the required information has been put on AERB website. Twenty queries received from various applicants under RTI Act were replied during the year. The information sought were mainly related to Mayapuri scrap yard incident. All replies are available in AERB website.

CHAPTER 11

INTERNATIONAL COOPERATION

11.1 INTERNATIONAL COLLABORATIVE STANDARD PROBLEM (ICSP) EXERCISE ON SMALL BREAK LOSS OF COOLANT ACCIDENT (SBLOCA)

The objective of the ICSP is to improve the understanding of important phenomena expected to occur in SBLOCA in PHWR, evaluate code capabilities by simulating an integrated experiment and suggest either code improvements or new experiments to reduce uncertainties.

Thermal hydraulic analysis of small break loss of coolant accident experiment on RD14M facility (Canada) was carried out using RELAP5 thermal hydraulic system code as part of the 'International Collaborative Standard Problem Exercise on HWR Code Predictions' organized by IAEA. The steady state qualification was carried out. Initial conditions for the analysis are in good agreement with the experimental data. The results of blind transient analysis and sensitivity analysis for RD-14M tests B9006 and B9802 were discussed at the third meeting in Vienna in 2009 August. Subsequently the experimental data were released and open calculations were performed. The open calculation results were presented in the 4th meeting held at Daejeon, Republic of Korea, in November 2010. In general, the open calculation predictions for both the tests B9006 and B9802 are in good agreement with the experimental data. However, the present analysis could not predict the fuel pin temperature oscillations observed in the test B9802 due to dryout/rewet phenomena. The capability and implementation of the horizontal stratification models in RELAP5 code may be studied and it may be further developed/improved.

11.2 INTERNATIONAL COLLABORATIVE STANDARD PROBLEM (ICSP) EXERCISE ON PWR DESIGN NATURAL CIRCULATION FLOW

The purposes of this IAEA ICSP is to simulate flow instability phenomena under natural circulation conditions and coupled containment/reactor vessel behavior in integral-type reactors, where, experimental data can be used to assess computer codes for reactor system design and analysis. This will also improve understanding of important phenomena expected to occur in a natural circulation integral type small reactors.

Double-blind calculations of two transient scenarios, namely SP-1 (Stepwise reduction in primary system volume at decay power) and SP-2 (Loss of feed water transients with ADS operation) have been carried out using RELAP5/SCADAP/MOD3.4. This is to understand the possible phenomena like natural circulation flow instability and loss of feed water transients with ADS operation in small integral natural circulation reactors. Initial conditions for the transient simulations were obtained by performing steady state calculations. In both the transient cases, the system falls into a two-phase oscillatory mode owing to low pressure instabilities due to core boiling, flashing, etc. Different flow physics in the secondary side can be expected when modeling the SG coils as single and three equivalent pipes that may reflect in the code prediction of transients, and hence, more emphasis could be laid on modeling of the secondary steam generator coils. Further, the model validation will be carried out as soon as the actual conditions from experiments are shared through the ICSP exercise.

11.3 PSA ACTIVITIES FOR IAEA-CANDU PSA WORKING GROUP

As a part of CANDU senior regulators group activities on PSA, the status on the comparison of PSAs among the CANDU operating countries were presented during the IAEA technical meeting held during 3-7 May, 2010 at Vienna, Austria. Based on the deliberations, a PSA expert group was established to address the open issues identified in the summary report. India is identified as a lead country for four of the nine PSA issues. This include: (i) preparation of the framework for CANDU-specific component database, (ii) preparation of framework for CCF event database, (iii) comparison of PSA standards, (iv) preparation of the discussion paper for various PSA risk measures. The position papers on these activities were prepared and sent to IAEA.

11.4 WORKING GROUP ON RISK ASSESSMENT ACTIVITIES

As a part of NEA/OECD activities, WGRISK was established in India. The Indian response to the questionnaire has been prepared on the technical documents on 'Best practice Guidelines for the Development and applications of Level-2 PSA related to Nuclear Power Plants' and 'PSA in the frame of Design and Commissioning of New NPPs'. The position paper on 'Use and Development of PSA in India' was prepared.

11.5 REGIONAL WORKSHOP ON DETERMINISTIC BEST ESTIMATE (BE) SAFETY ANALYSIS FOR ADVANCED NPPS

An IAEA regional workshop on Deterministic Best Estimate (BE) Safety Analysis for Advanced NPPs was hosted by AERB and jointly organized by IAEA and AERB. The regional workshop was held in AERB, Mumbai, 13-17 December 2010 and was designed for professional staff from regulatory authorities, utilities and design or technical support organizations involved in deterministic safety analyses and managers with responsibilities for safety analyses from the Asian Region. The purpose of the workshop was to address the application of Best Estimate and Uncertainty analyses by designers, operators, regulators and technical support organizations for the assurance of safety and reliability.

The workshop was inaugurated by Chairman, AERB. He emphasized the importance of deterministic safety analyses to confirm the adequacy of safety provisions. He also mentioned about the conservative approaches and the use of best estimate analysis together with an evaluation of the uncertainties. Dr. M. Dusic of IAEA presented the objectives of the workshop and IAEA activities and documents related to this subject. Prof. F. D'Auria, Italy, Dr. H. Glaeser, Germany and Prof. N. Cavlina, Croatia were the faculty identified by IAEA and delivered lectures on various aspects including current methods in deterministic safety analysis, deterministic safety analysis for operational events, uncertainty analysis methodologies etc. during the workshop. The on-going activities and capabilities on the deterministic safety analysis in NPCIL, BARC and AERB were also presented. Scientific staff from AERB, NPCIL, IGCAR and BARC attended the workshop. Scientific staff from Vietnam and Bangladesh also participated in this workshop.

IAEA Regional Workshop on Deterministic Best Estimate (BE) Safety Analysis for Advanced NPPs-Session in progress at AERB

11.6 IAEA-EBP KASHIWAZAKI-KARIWA RESEARCH INITIATIVE FOR SEISMIC MARGIN ASSESSMENT (KARISMA) BENCHMARK STUDY

AERB is a participant of the IAEA extra budgetary programme on 'Seismic Safety of existing NPPs'. This EBP focuses on quantifying available margins, understanding the behavior of structures, soil and equipment during earthquake and identification of main parameters influencing the response. AERB participated in two working areas of the EBP viz. WA2 dealing with re-evaluation of safety of existing NPPs and WA3 dealing with post-earthquake actions.

As a part of the activities related to WA2, AERB completed the modeling of the reactor building incorporating all details related to geological strata and ground motion parameters. Soil model was updated and report was submitted. Static and Eigen value analysis of the model under fixed based conditions were completed. The deflections, force results, etc at various locations in RB and the natural frequencies of the FE model was estimated from the analysis results. More realistic dynamic response of the model was simulated by soil structure interaction analysis. For capturing these effects, the soil media was idealized by several sets of translational springs that captured soil stiffness under both translational and rotational motion. The embedment effects were also taken into account by additional springs located on the peripheral walls of RB. It was observed that the results/values estimated by AERB were in good comparison with the mean values of the results from different participants.

AERB also completed the benchmarking exercise for residual heat removal system piping as part of WA2. Benchmarking of residual heat removal (RHR) piping system was carried out. Finite element model of the RHR piping was developed (Fig. 11.1 a) and response analysis was carried out. This included analysis for static loads, eigen value analysis (mode shapes given in Fig. 11.1 b) and response spectrum analysis. The results / values estimated by AERB were in very good comparison with the mean values of the results from different participants. Further work viz., time history analysis and capacity assessment of RHR piping are being taken-up.

(a) (b)

Fig. 11.1: Finite Model of RHR Piping

11.7 AERB-USNRC STANDARD PROBLEM EXERCISE (SPE) ON PERFORMANCE OF CONTAINMENT VESSEL UNDER SEVERE ACCIDENT CONDITIONS

A standard problem exercise (SPE3), 'Performance of Containment vessel under Severe Accident Condition' has been taken up under the framework of 'USNRC-AERB Nuclear Safety Cooperation Program'. The SPE is conceived as a round robin exercise based on the previous round robin analyses of the NRC/NUPEC 1:4-Scale Prestressed Concrete Containment Vessel model tests.

A kick off workshop for the SPE on Performance of Containment Vessel under Severe Accident Conditions was organized by AERB. The objective of the present SPE (SPE3) is to enhance knowledge in characterization of PCCVs and to assess the current practice and state of the art with respect to the calculation of response to severe accident conditions. The round robin is an opportunity to improve knowledge in the following areas: (1) local containment behavior under beyond design basis pressures, (2) characterization of leakage behavior as a function of pressure and temperature and (3) probabilistic aspects of containment response. The round robin analysis of containment performance involves assessment of the ultimate load capacity of a prestressed concrete Containment Vessel (PCCV) structure. This will be done in two stages. The first stage of the Robin Analysis will examine local effects in the containment model and second stage will focus on characterization of leakage as a function of pressure and temperature. Participants from different organizations like Scanscot Technology (Sweden), SANDIA (USA), David Evans and Associates, Inc (USA), NRC (USA), FORTUM (Finland), NECS (France), EDF (France), GRS (Germany), AERB (India), NPCIL (India), BARC (India) and IGCAR (India) participated in the workshop.

A team from AERB participated in the Round Robin Analysis of this SPE. In Phase-1 study, effect of friction of prestressing cable, interfacial behavior between steel liner and concrete were studied (Fig. 11.2). A full global model was also analyzed for ultimate capacity (Fig. 11.3).

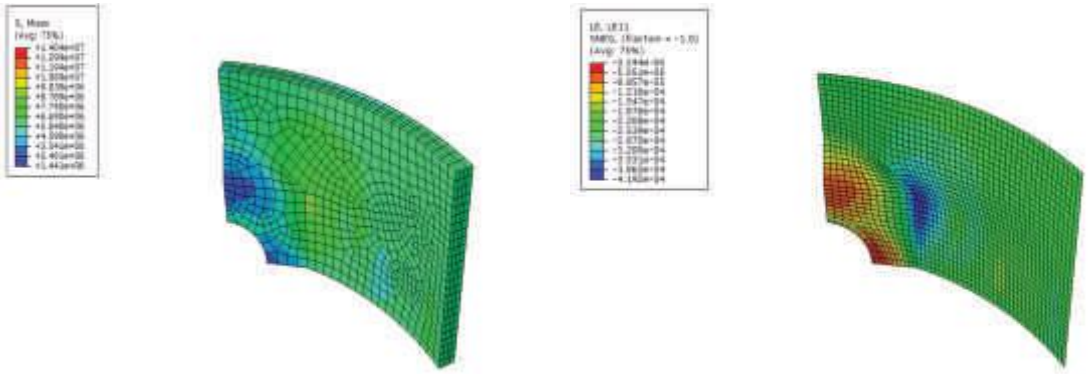
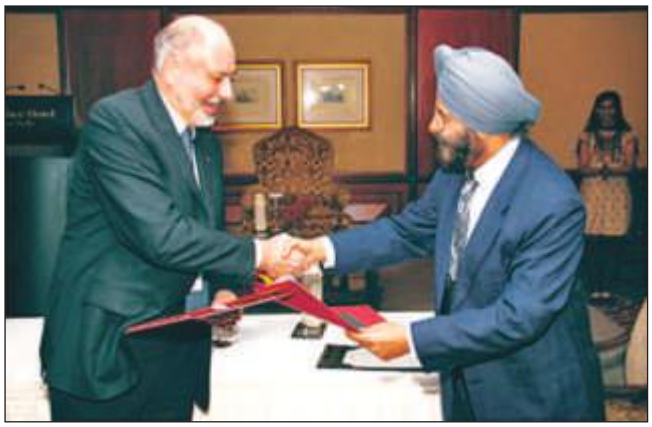


Fig. 11.2: Contour Plots of the Interfacial Behavior between Steel Liner and Concrete

Fig. 11.3: Plot of Stress Distribution in Containment due to Internal Pressure

11.8 AGREEMENT BETWEEN AERB - ASN AND AERB-IRSN

An agreement on the arrangement between AERB, India and ASN, France for the exchange of technical information and cooperation in the regulation of nuclear safety and radiation protection was signed on December 6, 2010 at New Delhi during the visit of French President Mr. Nicolas Sarkozy. The agreement was signed by Mr. S. S. Bajaj, Chairman, AERB and Mr. Andre Claude Lacoste, Chairman, ASN. This renews and updates the existing arrangement which is in force since 1999 and subsequently renewed in 2005. Both the countries agreed to exchange experts and technical and regulatory information related to radiation protection and to the safety of nuclear facilities. Another framework agreement on technical cooperation between AERB and IRSN, France was also signed by Mr. S. S. Bajaj and Mr. Jacques Repussard, Director General of IRSN for collaboration in the area of nuclear reactor safety covering areas such as exchange or secondment of staff, exchange of materials or software, joint studies and joint projects etc.



Mr. Jacques Repussard, Director General of IRSN and Mr. S. S. Bajaj, Chairman, AERB (Right) exchanging a framework agreement on cooperation in the area of nuclear safety on December 6, 2010 at New Delhi

Shri S. S. Bajaj, Chairman, AERB and Mr. Jacques Repussard, Director General of IRSN for the Agreement in the Area of Nuclear Reactor Safety

11.9 CONVENTION ON NUCLEAR SAFETY (CNS)

The CNS was adopted in Vienna on 17 June 1994 by a Diplomatic Conference convened by the IAEA. India ratified the Convention on March 31, 2005. Presently there are 72 Contracting Parties to the convention.

India submitted second national report in August 2010 for the fifth review meeting of the convention held in April 2011. Besides demonstrating compliance with the obligations of CNS, the report presented revision of AERB regulatory documents on design, operation and quality assurance of nuclear power plants. The report also brought out the progress on challenges and planned measures to improve safety identified by India during the 4th review meeting of the convention. The report contained updates on reliability and safety of digital instrumentation and control, licensing of the new designs for upcoming plants, reliability of passive systems, probabilistic safety assessments and developments in severe accident management programmes. The report also presented en-masse replacement of coolant channels and primary heat transport system feeders at NAPS-2 and KAPS-1 and measures taken to address the PHT feeder thinning and flow assisted corrosion of secondary system piping. Safety related activities like containment model testing and periodic safety review of operating NPPs were also described. India received a total of 122 questions / comments from the various contracting parties. The Indian National Report was very much appreciated. India reviewed the national reports of 15 Countries and raised a total of 107 questions.

A thirteen member Indian delegation led by Shri S.S.Bajaj, Chairman, AERB, participated in the 5th Review Meeting of CNS from April 4-14, 2011, held at the IAEA Headquarters, Vienna, Austria. The delegation consisted of senior officers from AERB, BARC, IGCAR, NPCIL and Permanent Mission of India in Vienna. 60 countries participated in the review meeting. India's presentation was scheduled on 6th April and was well attended. India presented updates on nuclear safety regulation, advances in safety research including experimental programmes, safety status of nuclear power plants in India, safety aspects of the reactors under construction and commissioning including the PFBR. The presentation included our initial response to Fukushima nuclear accident in Japan and formation of a high level committee by AERB to see the capability of Indian NPPs to withstand external events and adequacy of provisions available to ensure safety in case of such events. Indian regulations and practices on issues thrown up by this accident, especially external events and severe accident mitigation were also presented.

The contracting parties appreciated the refurbishments, backfits and upgrades related to safety which were implemented in Indian NPPs as a result of PSR and operating experience feedback such as that following a tsunami in 2004.

CHAPTER 12

QUALITY MANAGEMENT SYSTEM

12.1 QUALITY MANAGEMENT SYSTEM (QMS) OF AERB

AERB is entrusted with the responsibility of ensuring that use of nuclear energy and ionising radiation does not pose undue risk to the workers, members of the public and the environment in the country. In order to meet the required standard and continual improvement of quality in carrying out its functions, AERB has opted certification under ISO 9001 standard by Bureau of Indian Standards (BIS) for its consenting activities, regulatory inspection and preparation of regulatory documents since November 15, 2006.

As per ISO 9001 standard, a Quality Manual as level-I document and 13 numbers of procedures as level-II documents for implementation of Quality Management System (QMS) at AERB has been prepared. All the Level-I and Level-II documents were revised and the QMS of AERB was recertified as per new ISO 9001:2008 standard in November 2009.

As per the requirements laid in ISO procedures and Quality Manual for AERB, internal audit for various divisions of AERB were carried out in May 2010 and December 2010. There were 45 nos. of observations and no Non-Conformance (NC) reported for May 2010, while 40 nos. of observations and no NC reported for December 2010 audit. All the observations of both the internal audits were complied. Similarly, surveillance audit was carried out in December 2010 by BIS and no NC was reported by BIS. However, certain suggestions provided by BIS auditor have been implemented.

In order to enhance awareness level on QMS requirements and to improve competence of AERB personnel in performing their QMS functions, two programs on ISO 9001:2008 QMS were held on August 16, 2010 and on February 17, 2011 respectively. Lecture topics for first program were 'Guidelines for Auditors', 'Quality Assurance in NPPs' and 'Changes between ISO 9001:2008 and ISO 9001:2000'. Similarly, second program lecture topics were 'QMS Requirements', 'Experience of QMS Implementation in NPCIL', 'Quality Assurance in Transport of Radioactive Substances through Public Domain' and 'AERB Audit Observations'.

QMS Monitoring Committee (QMS-MC) of AERB met four times and reviewed the audit observations arising from internal audits carried out in the year 2010. Similarly, Executive Committee (EC) of AERB reviewed the audit reports.

As part of training for the newly recruited officers under OCRP-2011, a lecture on ISO 9001:2008 (QMS) was organized on February 25, 2011. Similarly, a two-day training program on ISO Standard (ISO 9001:2008) was conducted for 25 participants on April 27-28, 2011 to revalidate the certificates of internal auditors at AERB as per new ISO Standard.

Data analysis with respect to the observations and NCs in the both internal audit was carried out and corrective and preventive actions were taken.

Awareness program on QMS functions for AERB Auditors held in AERB Auditorium
(Shri R. Bhattacharya, MR-ISO and Dr. Devendra Mohan, Senior Scientist from BIS are seen in picture)

CHAPTER 13

HUMAN RESOURCE DEVELOPMENT

13.1 MANPOWER AUGMENTATION

Under the XIth plan 'Expansion Programme of AERB', DAE has sanctioned a total of 130 new posts under Scientific & Technical (103) and Administrative/Accounts (27) categories. AERB has taken steps to fill up these posts at various levels and through various channels. Scientific officers in the grade of SO(E)/SO(D) were inducted by direct recruitment and by inducting postgraduates through AERB Graduate Fellowship Scheme (AGFS) at IIT Bombay and IIT Madras.

During the year, the following manpower was inducted in AERB

- 22 Scientific Officers in the posts of Scientific Officers (E) & (D) joined AERB through open recruitment.
- Five Scientific Officers(C) were recruited (one SC candidate, one PH candidate & 3 OBC candidates) in order to meet the urgent manpower requirement of Radiological Safety Division, AERB and also to fill up the backlog vacancies of SC/ST/OBC/PH, exclusively against the special recruitment drive.
- 09 Scientific Officers (C) joined AERB through various Training Schools of DAE.
- Three students sponsored under AERB Graduate Fellowship Scheme for M.Tech. in 2008 joined AERB in August 2010.
- Eleven Officers/staff joined AERB through inter-unit transfer.
- A new post of Chief Administrative Officer was created in AERB. The post was filled up in August 2010.
- Three Administrative staff joined AERB (2 Upper Divn. Clerks & one Lower Divn. Clerk).
- Five students, 3 in IIT Madras and 2 in IIT Bombay were sponsored for M.Tech in August 2010.

As on March 31, 2011, the staff strength of AERB is 251, consisting of 208 Scientific & Technical and 43 supporting staff. Total sanctioned strength in AERB for XI plan is 343 comprising of 273 Scientific & Technical and 70 supporting staff.

13.2 IMPLEMENTATION OF PERSONS WITH DISABILITIES ACT, 1995 AND IMPLEMENTATION / WELFARE OF RESERVATION POLICY FOR SCHEDULED CASTES/TRIBES/OBC

During the year 2010-11 AERB conducted a special recruitment drive exclusively to recruit candidates belonging to SC/ST/OBC/PH and five Scientific Officers(C) were recruited (one SC candidate, one PH candidate & 3 OBC candidates). Rosters are maintained as per the orders on the subject. The backlog vacancies are being worked out and periodic Reports & Returns are being sent to DAE.

13.3 KNOWLEDGE MANAGEMENT

A 'Knowledge Portal' has been in operation during the year at the internal website of AERB, as part of knowledge preservation and easy retrieval. Training/teaching material, proceedings of Conferences and Seminars, Papers presented/published by AERB personnel and management information system were posted on the portal at regular intervals. National and international codes/guides/manuals are also being posted on the portal. Knowledge portal was reorganised for easy retrieval of information.

A well-equipped library is maintained in AERB. A total of 101 new publications have been added during the period and with this, the total collection of publications has gone up to 10,055. In addition, 25 Journals have been subscribed during the period. Reference and Information Services have been provided to the users and visitors of the Library. List of New Additions, World Nuclear News, NucNet News, NEI Newsletter, Bulletin of the Atomic Scientist Newsletter etc. are circulated in digital form regularly by sending e-mails to AERB Staff. Table of contents of new issues of important journals of AERB's subject interest available in Science Direct is regularly circulated by email alerts.

13.4 MANAGEMENT INFORMATION SYSTEM

The Corporate Human Asset and Resource Management System (CHARMS) has been installed in AERB. Various changes were incorporated in the CHARMS for suitability to AERB environment.

13.5 TRAINING

13.5.1 AERB Orientation Course for Regulatory Processes (OCRP-2011)

The OCRP-2011 was conducted during January 10 to March 03, 2011 for the scientists/engineers newly inducted in AERB. The course covered important topics related to functions of AERB, nuclear, industrial and radiation safety.

Site visits were organized to TAPS-3&4, Dhruva reactor at BARC and Advanced Centre for Treatment, Research and Education in Cancer (ACTREC) at Kharghar, Navi Mumbai. Through these visits the trainees were familiarized with the systems of PHWR, research reactor and radiation facilities. The safety measures provided in these units were explained to the Trainees. The valedictory function for the Course was held on 22nd March 2011, in which the certificates were distributed to the trainees. The feedback from the trainees and suggestions from senior officers of AERB for improvement would be incorporated in the future courses.

Shri S.K. Chande, Vice-Chairman distributing Certificates to Trainees of OCRP-2011

13.5.2 Orientation Course for DAE Graduate Fellowship Scheme (DGFS) Fellows

AERB sponsor M-Tech students from IIT-Mumbai and IIT-Madras under AERB Graduate Fellowship Scheme (AGFS). These students after completing M-Tech join AERB as SO(C). Three engineers, selected under AGFS, underwent training in Orientation Course for DAE Graduate Fellowship Scheme (DGFS) Fellows (OCDF) of Human Resource Development Division, BARC, Mumbai.

13.5.3 Administrative Training Institute of DAE

17 Scientific Officers, 5 officers of Administration & Accounts Divisions and 2 staff of AERB were nominated for the various training programmes conducted by the Administrative Training Institute, DAE

13.6 AERB TECHNICAL TALKS

Technical talks were arranged on the following topics.

a) 'ASME Sec. IX- Welding Qualifications' by Shri P.K. John, Technology Development Group, NPCIL. This talk covered Organisation of ASME Sec.-IX, Code requirement related to welding procedure qualifications, Code requirements related to welder performance qualifications, ASME grouping of materials and welding consumable and documentation.

b) 'Radiological Incident in Delhi' by Dr. A. U. Sonawane, RSD, AERB. The talk covered the description of the unfortunate radiological incident occurred in metal scrap market in Mayapuri area of Delhi, the measures and the regulatory actions taken to prevent recurrence of such incident.

c) 'Right to Information Act-2005' by Shri Achleshwar Singh, ATI, DAE. The talk covered several important aspects of RTI.

d) 'Effect of Earthquake and Tsunami on NPPs at Fukushima, Japan vis-à-vis Safety Review of Indian NPPs' by Shri A. D. Roshan, SSED, AERB. The talk presented technical details related to earthquake and tsunami during the incident in Fukushima, Japan.

e) 'Events after Earthquake and Tsunami in NPPs at Fukushima, Japan' by Shri A. P. Garg, OPSD, AERB. The talk gave an overview of the events that had taken place following earthquake and tsunami incident in Fukushima, Japan.

13.7 TRAINING ACTIVITIES/AWARENESS PROGRAMMES

- One day special meet was organised by AERB on 'Safety and Security of Industrial Radiography Sources in India' on April 22, 2010 at Mumbai for industrial radiography users. The objective was to make them aware about the current regulatory requirements for industrial radiography. About 400 participants took part in the above workshop.

The objective of the programme was to familiarize about the application of radiation, associated hazards & control measures and the current regulatory requirements. About 35 participants attended the programme.

- Two awareness programmes with title as 'One Day Awareness Programme for Research Facilities using Open Radioisotopes' were held on July 30, 2010 and August 06, 2010 in AERB premises. The objective of the programme was to generate awareness amongst the users and to enhance good safety practices for effective implementation of regulatory measures at the user level. One hundred and fifteen delegates actively participated in the programme.

Special One Day Meet on 'Safety and Security of Industrial Radiography Sources in India'
(Shri S. S. Bajaj, Chairman, AERB and Shri S. K. Chande, Vice-Chairman, AERB are seen in the picture)

- One officer from RSD, AERB participated in a one day awareness programme on 'Application of Radiation Technology in Medical Sciences 2010' on May 15, 2010, at North Eastern Indira Gandhi Regional Institute of Health and Medical Sciences (NEIGRIHMS), Shillong. The objective of the programme was to make aware the participants, mainly doctors, college & university students, professors etc, about the application of radioisotopes and x-rays in the field of medical and research. About 450 participants attended the programme.

- Members of Industrial Group were deputed as faculty for one day awareness Programme on 'Safe Handling of Well Logging Sources' organized at Kakinada by Andhra Pradesh State Government for officials of well logging institutions on June 28, 2010.

- One officer from RSD, AERB delivered lectures in the special training program on 'Safety in Well Logging' at Institute of Petroleum Safety, Health & Environment Management (IPSHEM) of Oil and Natural Gas Corporation Limited (ONGC), Goa during September 27 - October 1, 2010. The objective of the programme was to familiarize about the application of radiation in the field of nucleonic gauges, associated hazards & control measures and about the current regulatory requirements. About 20 participants attended the programme.

- A one day refresher programme for industrial radiographers and site-in charges, especially for those who were out of the field of radiography for more than five years, was conducted by RSD, AERB on November 10, 2010 at AERB, Mumbai. The objective of the programme was to refresh and

update the knowledge of safety, security and regulatory requirements. At the end of the programme the participants were evaluated by conducting written examination followed by vive-voce. Seventeen participants attended the programme.

- A one day awareness programme on radiation safety for gas mantle manufacturing Industries was held on November 11, 2010. The objective of the programme was to create awareness amongst the users of Thorium Nitrate users in Gas Mantle Industries. In the programme, in addition to other safety aspects, the users were also advised regarding safe disposal of the empty drums. About 20 participants attended the programme.

- Two officers were deputed as faculty members in one day awareness Programme on 'Radiation Safety Aspects in Oil Well Logging/Nucleonic Gauges' organized at Oil India Limited, Duliajan, Assam on November 24, 2010. The objective of the programme was to familiarize about the application of radiation in the field of nucleonic gauges, associated hazards & control measures and about the current regulatory requirements. The programme was conducted in Hindi language. About 50 participants attended the programme.

- Officers from RSD, AERB conducted a training programme at Delhi University during the period December 01-03, 2010. The objective of the programme was to conduct a training programme for Radiological Safety Officer. At the end of the training programme, a written exam followed by vive-voce was also carried out for the evaluation of the candidates. A total of 38 participants from various departments participated in the training programme.

- A one day Workshop was organized on December 21, 2010 for manufacturers and suppliers of medical X-ray diagnostic equipment in India. The main objective of Workshop was to familiarize the manufacturers and suppliers with the requirements of IS 13450 for Type Approval of equipments used in the field of diagnostic radiology. A total of 42 participants attended the programme.

- One day 'Awareness Programme on Industrial Radiography' was conducted at Jhajjar Thermal Power Station, Jhajjar, Haryana on December 24, 2010. The objective of the programme was to generate awareness amongst the radiography contract awarding parties, radiography agencies, RSOs and Site-in-charges. About 35 participants attended the programme.

13.8 NATIONAL TRAINING

Dr. A. U. Sonawane, RSD, AERB completed the National Assessor training course for Medical Imaging Services (MIS) organised by the National Accreditation Board for Hospitals & Healthcare Providers (NABH). The course is prerequisite for empanelling candidates as 'Assessors' for carrying out assessment of MIS against NABH accreditation standards for MIS. Dr. Sonawane has also qualified the Level-III examination for Non-Destructive Testing (NDT) in industrial radiography conducted by the Indian Society for Non Destructive Testing (ISNT).

13.9 NOMINATION FOR HIGHER QUALIFICATION IN NUCLEAR SAFETY

AERB had nominated Shri S.K. Pradhan, SADD, AERB to enroll in the KINS-KAIST International Nuclear Safety Master Degree Programme during August 1, 2009-December 27, 2010 at Daejeon, Republic of Korea. The 'KINS-KAIST International Nuclear Safety Master's Degree Program' is conducted by International Nuclear Safety School (INSS) of Korea Institute of Nuclear Safety (KINS) in collaboration with Nuclear & Quantum Engineering (NQE) Department of Korea Advanced Institute of Science & Technology (KAIST). Courses on nuclear safety, radiation safety and emergency preparedness, nuclear safety regulation were covered and he carried out a research work titled 'LBLOCA with uncertainty analysis for Wolsong unit-I CANDU Reactor using MARS code'. 'On the Job Training' at KINS was also a part of the programme. He was awarded degree of Master of Science in Nuclear and Quantum Engineering in February, 2011.

CHAPTER 14

SAFETY RESEARCH PROGAMME

14.1 SAFETY RESEARCH PROGAMME

One of the objectives of AERB is to promote safety research and related activities relevant to safety and regulatory work. For this, a Committee for Safety Research Programmes (CSRP) has been constituted to frame rules, regulations and guidelines and to evaluate, and recommend grants for the research projects and to monitor their progress periodically. The Committee also recommends financial assistance to universities, research organizations and professional associations for holding symposia and conferences of interest to AERB. The Committee met two times during the year and deliberated on 11 new project proposals and recommended Grant-in-Aid for 5 new projects as given in Table 14.1. It also approved the renewal of 2 ongoing projects as given in Table 14.2.

In addition, financial support was provided to 32 seminars, symposia and conferences. The sub-committee of CSRP met thrice to clear the applications seeking financial support from AERB for conducting the seminars/conferences.

Based on the recommendations from the committee, AERB Executive Committee has enhanced the annual budget of SRP from 1 crore to 2.5 crores with effect from 2010-11.

Table 14.1: New Research Projects Approved

Sr. No.	Project Title	Principal Investigator/ Organization	Principal Coordinators/ Collaborators
1.	Evaluation and Inter-Comparison of QA Measurements in Radiation Oncology	Shri C. Ramakrishna Rao	MNJ Institute of Oncology, Hyderabad
2.	A Study on Radioactivity in Phosphogypsum based Building and Construction Materials and Indoor Radon Inhalation Dose Estimate in Tamil Nadu	Dr. P. Shahul Hameed	J. J. College of Engineering & Technology, Thirchy
3.	Numerical Stimulation of the Response of Nuclear Containment subjected to Aircraft Crash	Prof. Pradeep Bhargava	IIT-Roorkee, Roorkee
4.	Influence of Stiffness of the System and Heat Input Waveform on Transient CHF in Horizontal Channels under LPLF Conditions	Dr. S.V. Prabhu	IIT-Bombay, Mumbai
5.	Development of a 1-D Thermal Hydraulic Code for Computation of Unsteady Steam-Water Flow and Supercritical Water Flow in Horizontal and Vertical Channel Type Reactors	Prof. Man Mohan Pandey	IIT-Gandhi Nagar, Gandhi Nagar

Table 14.2: Research Projects Renewed

Sr. No.	Project Title	Principal Investigator	Organization
1.	Evaluation of Patient Specific Dose for Optimised X-ray Diagnostic Imaging System in a Rural Setup	Dr. V. S. K. Vijaykumar	MGMMT, Bhimavaram
2.	Enhancement of Durability of Concrete Structures using Microbes	Prof. A. Mukherjee	Thapar University, Patiala

14.2 WORKSHOPS/SEMINARS

14.2.1 Discussion Meet on Internal Dosimetry for Nuclear Facilities

Internal dosimetry programme is followed at various nuclear fuel cycle facilities for the estimation of internal radiation dose. Various methodologies and procedures are used for internal dose assessment of different radionuclides. The use of operating experience is important for improving internal dosimetry programme. AERB organized one day meeting titled, 'Discussion Meet on Internal dosimetry for Nuclear Facilities' on August 20, 2010 at Niyamak Bhavan, AERB, Mumbai. The main objective of the meet was to discuss the internal dosimetry programme at various nuclear fuel cycle facilities. The meeting was attended by delegates from BARC, NPCIL, UCIL, NFC, IRE, IGCAR and AERB. The discussion meet addressed various issues including the harmonization of procedures, detection limits, frequency of measurement, analysis method and accuracy of the dose assessments.

14.2.2 Discussion Meet on Application of the Concepts of Exclusion, Exemption and Clearance in Nuclear Fuel Cycle and Radiation Facilities

Radiation sources and practices associated with radiation facilities in India are governed by the Atomic Energy (Radiation Protection) Rules 2004. As per sections 5 and 6 of the rules and the current IAEA strategy, some of the radioactive practices and sources within practices need not be subjected to regulatory control based on the principle of exclusion, exemption and clearance. Exclusion means the deliberate exclusion of a particular category of exposure from the scope of an instrument of regulatory control on the grounds that it is not considered amenable to control through the regulatory instrument in question. Exemption is the determination by the regulatory body that a source or practice need not be subject to some or all aspects of regulatory control on the basis that the exposure (including potential exposure) due to the source or practice is too small to warrant the application of those aspects. Clearance is the removal of radioactive materials or radioactive objects within authorized practices from any further regulatory control by the regulatory body. AERB organised a discussion meet on 'Application of the Concepts of Exclusion, Exemption and Clearance in Nuclear Fuel Cycle and Radiation Facilities' on January 20, 2011. The objective of the meeting was to discuss the strategy of Exclusion, Exemption and Clearance of radioactive solid materials and application of the same in use of radiation sources and practices. The meeting was attended by delegates from NPCIL, BARC, IGCAR, AERB and other DAE facilities. The meet provided an opportunity to all the participants to have a discussion on various aspects related to Exclusion, Exemption and Clearance and also an insight into the application of these concepts in day to day plant operation.

14.2.3 Discussion Meet on Review of Systems for Operating Experience Feedback

Operational experience feedback (OEF) is a valuable source of information for learning and improving the safety and reliability of the nuclear installations. The practices of review and analysis of deviations from the normal operating conditions, events and significant events already exists at NPCIL. The event reporting system in India was formally established in 1991. In order to strengthen the operational experience feedback system, a new two-tier event reporting system was established in 2002. AERB has also published a safety guide on Operational Safety Experience Feedback on Nuclear Power Plants (AERB/NPP/SG/O-13) in the year 2006. In order to further strengthen the OEF system, AERB organized a discussion meet on 'Review of Systems for Operating Experience Feedback' on March 10 - 11, 2011. The objective of this meet was to share the experience with regard to event reporting system, AERB safety guide AERB/SG/O-13, external events, events and significant events at Indian facilities, low-level and near miss events, development and review of technical specifications for different type of NPPs, development of event reporting system for NPP projects and the experience during long shutdowns. The meet was attended by eighty delegates from NPPs, NPCIL, BHAVINI, BARC, IGCAR, HWB and AERB. Thirty three presentations were made on the OEF practices in various plants / organizations. The discussion meet brought out the need for review of the event reporting criteria, sharing of experience of the events which are outside the scope of reporting criteria but have significant lessons, formulation of reporting criteria for construction sites and periodic assessment of the OEF system in various facilities.

14.2.4 Discussion Meet on Challenges and Strategies in Industrial Safety at DAE Construction Sites

In view of the fatal accidents at various construction sites of NPCIL, AERB had earlier conducted discussion meets on 'Industrial Safety - Focus on Fatal Accidents' with concerned Heads of the DAE Units in the year 2004 and 2005. In view of fatal accidents at various construction sites that continued to occur in subsequent years and to take a stock of action plans drawn in earlier above mentioned meets, a discussion meet on 'Challenges and Strategies in Industrial Safety at DAE Construction Sites' was organized at AERB with concerned Heads from all DAE units on March 21,2011. The discussion was focused on the areas like corporate safety policy &

planning, corporate and site–safety organizations, interaction of mega contractors & sub-contractors with departmental staff, effectiveness of construction safety documentation, workplace engineering measures, safety training, effectiveness of supervision (both departmental and contractor), medical management at construction sites, issues related to accountability of employees/contractors towards job safety, efforts to enhance safety culture etc. Based on the discussions, action plans were formulated for enhancing safety standards in construction activities.

14.2.5 Theme Meeting on Hydrogen Management Aspects in Nuclear Power Plants

The theme meeting on 'Hydrogen Management Aspects in Nuclear Power Plants' was organised in AERB on December 16, 2010. Participants from BARC, NPCIL, AERB and SRI attended this one day theme meeting. The objective of the meeting was to understand the current status of hydrogen management strategies being developed in DAE and to identify the areas for future work in managing hydrogen threat to containment integrity. Important issues on hydrogen management aspects including development of recombiners, analytical capabilities are discussed and. Key areas identified for future work include development, testing, large scale production and deployment of hydrogen recombiners, other hydrogen management measures and hydrogen monitoring systems in containment. Development of capabilities for application of CFD codes for hydrogen distribution calculations is also identified for further work.

14.2.6 Theme Meeting on Size of Sterilized Zone

A theme meeting was organized on 'Size of Sterilized Zone' on September 01, 2010 to have wider views on the subject. The objective of the meeting was to arrive at strategies for sterilized zone around nuclear power plants. Chairman, AERB gave an historical perspective of the issue and mentioned the need to reevaluate the requirements for sterilized zone for its better utilization. Director, BARC said that USNRC launched a new programme to eliminate over conservatism due to studies with inadequate methods and inadequate computer resources. In this context and in view of the projected increase in Indian nuclear power generation capacity, he stressed the need to develop scientific tools, methodologies and regulatory standards to reduce over conservatism without compromising public safety.

Presentations were made during the meeting on aspects such as international approaches on sterilized zone and current status of sterilized zone around existing nuclear power plants. It was noted that there exists a relation directly or indirectly among dose levels, dose computation methodologies (e.g. use of TEDE concept), graded dose criteria for various categories of plant states up to severe accidents, and sterilized zone in severe accident management strategy.

Panel Discussion of the Meet on 'Challenges and Strategies in Industrial Safety at DAE Construction Sites'
(Shri S. K.Chande, Vice-Chairman, AERB, Dr. Prabhat Kumar, Project Director, BHAVINI
Shri R. Gupta, CMD, UCIL, Shri R. N. Jayaraj, CE, NFC, Shri T. K. Haldar, Addl. CE, HWB,
Shri Umesh Chandra, Sr. ED (Safety), NPCIL and
Shri R. Bhattacharya, Secretary, AERB are seen on the dais)

CHAPTER 15

OFFICIAL LANGUAGE IMPLEMENTATION

AERB continued its efforts to ensure effective implementation of official language policy and to increase use of Hindi in official work. Consequently, more than 5000 letters in Hindi / Bilingual form were issued during the year.

1) Unicode system was uploaded on 144 Computers during the year.

2) With a view to impart awareness about the need to use Hindi in official work, Chairman, OLIC and AD (OL), AERB attended divisional meetings and briefed the participants about the rules and regulations pertaining to Rajbhasha and emphasized on the importance of Hindi / Bilingual correspondence. The current data on use of Hindi was reviewed and measures to increase correspondence in Hindi were discussed.

3) To increase use of Hindi and bilingual correspondence, all Directors and Heads of Divisions were requested to identify standard letters, proformae & notings and send them to Rajbhasa Section for translation. As a result, the 32 letters were received from various Divisions. Consequently the Hindi/Bilingual Correspondence by AERB have increased during the last two quarters. In comparison with 809 letters issued in the July-Sep., 2010 quarterly, total 2454 Hindi/Bilingual letters were issued during Oct.-Dec., 2010.

4) For publication of AERB Glossary of 'Scientific and Technical Terms' of AERB, the first meeting of the members of Scientific and Technical Glossary Commission and Departmental Officials of AERB was held during Oct. 25-29, 2010 and total 812 words were discussed and finalized during the meeting.

5) During January to March, 2011, two guides namely 'Safety classification and seismic categorization for structures, systems and components of pressurized heavy water reactors' (AERB/NPP-PHWR/SG/D-2; 2003) and 'Quality assurance in the manufacture of items for nuclear power plants' (AERB/SG/QA-3; 1998) were published in Hindi.

6) The Annual Report of year 2009-10 was published in Hindi.

7) Two Half Yearly Newsletters were published in Hindi.

8) Hindi magazines like India-Today, Grahashobha, Kadambini, Sarita and Health are subscribed for the use of officers and staff of AERB.

9) A one day computer workshop on Unicode system was organized by AERB on September 01, 2010 at V.S. Bhavan under the auspices of Joint Official Language Co-ordination Committee of the four units situated in Anushaktinagar (AERB, HWB, DCSEM & DPS) wherein nineteen officers/employees of all four units were trained. The participants were trained in uploading and use of Unicode system on computers. Apart from this, the participants were also taught easy procedure of Hindi typing in computers. Practice in Hindi typing was also rendered to the participants. The participants were also briefed about the rules related to Rajbhasha.

10) Four officers/employees of AERB participated in the competitions like Hindi essay, Hindi typing and noting and drafting organized by DAE at all India level. Shri Shekhar Chavan, APO of AERB secured first prize in Essay in Region 'B' and Shri Kavi Upreti, Scientific Officer (C) of AERB secured second position in Region 'A'.

11) A lecture was delivered on use of Unicode System on Computer by Shri Vaibhav Gholap, AERB on June 25, 2010 at Indian Maritime University, Navi Mumbai.

AERB members of OLIC attending Joint Official Language Coordination Committee
(Shri A. Ramakrishna, Chairman, OLIC and other Members of OLIC are seen in the picture)

CHAPTER 16

AWARDS AND ACHIEVEMENTS

16.1 AWARDS

Shri S. S. Bajaj, Chairman, AERB Receiving the SRESA Life Time Achievement Award

Shri S. S. Bajaj, Chairman, AERB was honoured with Society for Reliability and Safety (SRESA) life time achievement award in recognition of his significant and multifarious contributions in the area of nuclear reactor safety. Shri Bajaj has done several pioneering works in the field of nuclear reactor safety during his tenure at NPCIL by guiding the team of experts in the field of deterministic PSA. He led the team for developing several thermal-hydraulic computer codes at NPCIL. The first level-1 PSA study (internal events, full power) for representative PHWR and BWR from NPCIL have been carried out under his leadership. Work on level-2 PSA of PHWR was carried out under his leadership. The award was conferred by SRESA at the second International Conference on Reliability, Safety & Hazard (ICRESH-2010) on December 16, 2010 in Navi Mumbai.

16.2 ACHIEVEMENTS

Following AERB officials have been awarded with Doctor of Philosophy (Ph.D.) in Physics from Mumbai University during the year.

- Dr. A. U. Sonawane on 'Radiation protection of patients in x-ray diagnostic radiology in India' in July 2010.
- Dr. P. K. Dash Sharma on 'Some safety and dosimetry aspects of an indigenously developed medical linear accelerator' in September 2010.

CHAPTER 17

MISCELLANEOUS

17.1 INTERACTION WITH OTHER AGENCIES

17.1.1 Bureau of Indian Standards (BIS)

Shri R. Bhattacharya, Secretary and Director, IPSD, AERB is a member of BIS Occupational Safety & Health and Chemical Hazards Sectional Committee, CHD 8 and convener of its Sub-Committee CHD 8:2 and is involved in review and revision of BIS documents.

17.1.2 Ministry of Environment and Forests (MoEF)

Ministry of Environment and Forests has constituted two separate environment appraisal committees for nuclear facilities: 1) Civilian Nuclear Facilities, 2) Strategic Nuclear Facilities. Secretary, AERB is a member of both these committees and has actively contributed in reviewing the terms of reference of new projects such as proposed nuclear power plant at Jaitapur, Gujarat and Madhya Pradesh.

17.2 RETIREMENTS ON SUPERANNUATION

The following AERB officials retired during the year. AERB places on record the significant contributions made by them

- Shri S.E. Kannan, Director, Safety Research Institute (SRI), Kalpakkam (May 31, 2010).
- Shri K. C. Upadhyaya, SO/F, RSD (May 31, 2010).
- Dr. Om Pal Singh, Secretary, AERB and Director, ITSD (July 30, 2010).
- Dr. I.A. Patwegar, SO/G, NPSD (August 31, 2010).
- Shri S. K. Warrier, SO/H+, NPSD (October 31, 2010).
- Dr. Prabir C. Basu, Director, C&SED (voluntary retirement on December 28, 2010).
- Shri R.K. Chugha, SO/G, OPSD (January 31, 2011).

17.3 INTERNATIONAL WOMEN'S DAY CELEBRATION

A cultural programme was organized by lady employees of AERB on International Women's Day on March 8, 2011. This year was the centenary year, i.e, the 100th Women's Day Celebration. The Chief Guest of the programme was Smt. Suzie Bajaj and other invitees present were: Smt. Surekha Chande, Smt. Seema Gupta, Smt. Swati Gujrathi, Smt. Lakshmi Ramakrishna and Smt. Padma Srivasista. All the ladies actively participated in various competitions and games. Prizes were distributed to the winners. The success of the programme was in the team spirit shown by all the ladies who worked collectively to make it a memorable event.

AERB Women's Day Celebrations-March 8, 2011

CHAPTER 18

DEPUTATIONS ABROAD

Name of the Officer	Period		Venue	Purpose of deputation
	From	To		
Shri S.K. Chande	12/04/2010	16/04/2010	Beijing, China	International expert to attend IAEA meetings to Evaluate Technical Events related to safety of nuclear installations
Dr. P. C. Basu	21/04/2010	23/04/2010	Beijing, China	5th Meeting of SWT of WA 3 IAEA-EBP on Seismic Safety for existing NPP's
Shri R. B. Solanki	03/05/2010	07/05/2010	Vienna, Austria	IAEA Technical meeting on probabilistic safety analysis (PSA) of CANDU reactors
Dr. Om Pal Singh	10/05/2010	14/05/2010	Vienna, Austria	Consultants Meeting to prepare the terms of reference Midterm strategy plan for the evaluation and training providing group
Shri S. A. Hussain	17/05/2010	21/05/2010	Vienna, Austria	Open ended Technical Meeting of Technical and Legal Experts for sharing of information as to status of implementation of the code of conduct on the safety and security of radioactive sources
Dr. P. C. Basu	17/05/2010	19/05/2010	Vienna	IAEA 1st review meeting of KARISMA & the 3rd organizing committee meeting
Dr. P. C. Basu	20/05/2010	21/05/2010	Vienna	Workshop on recent trends on seismic fragility evaluation
Shri K. Srivasista	31/05/2010	04/06/2010	Vienna, Austria	IAEA Technical Meeting on safety culture during pre-operational phases of new NPPs, sharing experience and learning valuable lessons.
Shri S K Chande	31/05/2010	04/06/2010	Vienna	IAEA consultancy meeting and the meeting of the advisory committee of incident reporting system
Shri Mahendra Prasad	07/06/2010	11/06/2010		SloveniaIAEA Technical Meeting on Application of Advanced Safety Assessment Methods
Shri S K Chande	07/06/2010	10/06/2010	Paris, France	Steering committee meeting of Committee on Nuclear Regulatory Activities CSRI & Committee on Safety of Nuclear Installations (CSNI) of OECD/NEA
Shri S.S. Bajaj	15/06/2010	17/06/2010	Hungary	17th Annual Meeting of WWER Regulators Forum
Shri R.I. Gujrathi	15/06/2010	17/06/2010	Hungary	17th Annual Meeting of WWER Regulators Forum

Shri T. S. Padmanabhan	21/06/2010	25/06/2010		Vienna, Austria International Conference on Operational Safety Experience and Performance of Nuclear Power Plants and Fuel Cycle Facilities.
Shri S.K. Dubey	05/07/2010	08/07/2010	Pisa, Italy	IAEA Technical Meeting on Heat Transfer Thermal Hydraulics and System Design for Super critical Pressurised Water Cooled Reactors
Shri R I Gujrathi	05/07/2010	09/07/2010	Sydney, Australia	Lecture for IAEA workshop on Ageing Management for research Reactors
Shri A D Roshan	06/07/2010	09/07/2010	Vienna	IAEA Technical Meeting on Topical issued on Infrastructure development common challenges on site selection for NPP Programme
Shri R K Singh	19/07/2010	23/07/2010	Vienna	IAEA Consultancy Meeting to Develop an initial draft proposed for International agreement
Dr. P C Basu	18/08/2010	24/08/2010	Vienna	Consultants meeting of IAEA EBP on Seismic Safety of existing NPP's
Shri L B Mahale	30/08/2010	02/09/2010	Vienna	IAEA Technical Meeting on Nuclear Security objectives and Fundamental Principles
Shri S Harikumar	01/09/2010	03/09/2010	Vienna	IAEA Extra Budgetary Programme on International Generic Ageing Lessons Learned (IGALL) Steering Group Meeting
Shri S Harikumar	07/09/2010	9/9/2010	Paris	OECD/NEA Task Group meeting for preparation of Green book on Long Term operation of NPP's
Shri S S Bajaj	20/09/2010	24/09/2010	Vienna	IAEA General Conference & Senior Regulator's forum
Shri K J Vakharwala	28/09/2010	30/09/2010	Buenos Aires, Argentina	Member of India-Argentina 1st Seminar
Shri S S Bajaj	30/09/2010	01/10/2010	Vienna, Austria	To attend 28th IAEA meeting of the Commission on safety standards
Shri Amit Sen	04/10/2010	08/10/2010	Bali, Indonesia	IAEA Regional Training Course of Security on Radioactive Sources
Shri Pravin Patil	04/10/2010	08/10/2010	Bali, Indonesia	IAEA Regional Training Course of Security on Radioactive Sources
Shri Bibekananda	04/10/2010	08/10/2010		Bali, Indonesia IAEA Regional Training Mishra Course of Security on Radioactive Sources
Shri R Bhattacharya	05/10/2010	06/10/2010	Vienna	Joint technical meeting of the IAEA/NEA/FINAS National Co-ordinators
Shri R S Rao	11/10/2010	15/10/2010	Cologne, Germany	ASTEC users club meeting
Shri S K Chande	11/10/2010	15/10/2010	Vienna	To attend Biennial meeting of INES National Coordinators

Shri Diptendu Das	12/10/2010	14/10/2010	Lyon, France	To participate in World Congress of Emulsions
Shri S N Rao	18/10/2010	22/10/2010	Vienna	Pre meeting presentation on New Manual Guidance for IRS coding and Joint IAEA/NEA Technical Meeting of the IRS National Coordinators
Shri S T Swamy	01/11/2010	03/11/2010	Pargue, Czech	Republic International Topical Meeting on VVER-2010 experience & perspective
Shri S K Chande	08/11/2010	12/11/2010	Shanghai, China	Annual meeting of the Sr. Regulators of countries operating CANDU type reactors
Shri P K Baburajan	09/11/2010	12/11/2010	Daejon, Korea	To attend IAEA consultancy meeting on International collaborative standard problem on comparison of heavy water reactor thermal hydraulic code predictions with small break loss of coolant accident experimental data
Dr. Pankaj Tandon	09/11/2010	12/11/2010	Vienna, Austria	International symposium on standard application and Quality Assurance in Medical Radiation Dosimetry
Dr. P C Basu	24/11/2010	26/11/2010	Japan	1st Kashiwazara International Seismic Safety Symposium
Shri R Bhattacharya	30/11/2010	02/12/2010	Vienna	2nd Meeting of Steering Committee of Human Resources for Regulatory Bodies in Member states with NPP's
Shri D Bhattacharya	06/12/2010	10/12/2010	Vienna, Austria	IAEA Technical Meeting on the Development of a Safety Guide on Commissioning of NPP
Shri S K Chande	06/12/2010	07/12/2010	Paris, France	29th Meeting of Committee on Nuclear Regulatory Activities (CNRA) and 48th Meeting of Committee on Safety of Nuclear Installations (CSNI)
Shri S K Chande	08/12/2010	09/12/2010	Paris, France	48th Meeting of the Committee on Safety of Nuclear Installations (CSNI)
Shri J Arunan	15/02/2011	18/02/2011	Vienna	IAEA Technical Meeting on Safety Culture overright and Assessment
Shri S Harikumar	27/02/2011	24/02/2011	Paris, France	2nd meeting of CNRA Sr. Task Group for preparation of Green book on long Term Operations of NPP's
Shri J Koley	23/03/2011	25/03/2011	Paris, France	6th Meeting of the CNRA working group on the Regulation of New Reactors (WGRNR) held in the OECD Convention Centre, Paris, France
Shri R I Gujrathi	28/03/2011	28/03/2011	Netherland	IAEA Integrated Safety Assessment of Research Reactors Mission to the high flux reactors

APPENDIX

PUBLICATIONS

A. JOURNALS

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ANNEXURE

LIST OF ABBREVIATIONS

AAFR	:	Additional Away From Reactor
ACI&FS	:	Advisory Committee on Industrial & Fire Safety
ACNS	:	Advisory Committee on Nuclear Safety
ACOH	:	Advisory Committee on Occupational Health
ACPSR	:	Advisory Committee for Project Safety Review
ACPSR-FCF	:	Advisory Committee for Project Safety Review for Fuel Cycle Facilities
ACRS	:	Advisory Committee on Radiological Safety
ACTREC	:	Advanced Centre for Treatment, Research & Education in Cancer
AEC	:	Atomic Energy Commission
AERB	:	Atomic Energy Regulatory Board
AFR	:	Away From Reactor
AGFS	:	AERB Graduate Fellowship Scheme
AHP	:	Analytic Hierarchy Process
ALARA	:	As Low As Reasonably Achievable
ALPAS	:	Automatic Liquid Poison Addition System
AMD	:	Atomic Minerals Directorate for Exploration and Research
ARA	:	Application for Renewal of Authorization
ARIS	:	AERB-RSD Information System
ASN	:	French Authority for Nuclear Safety
BARC	:	Bhabha Atomic Research Centre
BAR	:	Burnable Absorber Rods
BE	:	Best Estimate
BHAVINI	:	Bhartiya Nabhkiya Vidyut Nigam
BIS	:	Bureau of Indian Standards
BRIT	:	Board of Radiation and Isotope Technology
BSM	:	Beach Sand Minerals
BSMSC	:	Beach Sand Minerals Safety Committee
BU	:	Burn Up
CBS	:	Computer Based System
CCC	:	Construction Completion Certificate
CCF	:	Common Cause Failure
CDF	:	Cumulative Damage Frequency
CESC	:	Civil Engineering Safety Committee
CESCOP	:	Civil Engineering Safety Committee for Operating Plants
CGPS	:	Cover Gas Purification System
CHARMS	:	Corporate Human Asset Resource Management System
CNS	:	Convention on Nuclear Safety
CPSAR	:	Control & Protection System Absorber Rods
CSRP	:	Committee for Safety Research Programmes
CT	:	Computed Tomography
CTS	:	Cobalt Teletherapy Sources
DAE	:	Department of Atomic Energy
DBGM	:	Design Basis Ground Motion
DBFL	:	Design Basis Flood Level
DCHS	:	Dual Control Hot Standby
DEM	:	Digital Elevation Model
DFRP	:	Demonstration Fast Reactor Fuel Reprocessing Plant
DG	:	Diesel Generator
DGCA	:	Director General of Civil Aviation
DGFS	:	DAE Graduate Fellowship Scheme
DHX	:	Decay Heat Exchanger
DRS	:	Directorate of Radiation Safety
DSRC	:	Design Safety Review Committee
DU	:	Depleted Uranium / Delhi University
EBP	:	Extra Budgetary Programme
ECCS	:	Emergency Core Cooling System
ECIL	:	Electronics Corporation of India Ltd
ECILSC	:	Electronics Corporation of India Ltd. Safety Committee

ECT : Eddy Current Testing

EEPC : Engineering Export Promotion Council

EMCCR : En-Masse Coolant Channel Replacement

EMFR : En-Masse Feeder Replacement

EMTR : Emergency Transfer

EPP : Emergency Preparedness Plan

ESL : Environmental Survey Laboratory

EZ : Exclusion Zone

FA : Fuel Assemblies

FAAC : Fatal Accident Assessment Committee

FBTR : Fast Breeder Test Reactor

FCCI : Fuel Clad Chemical Interaction

FCMI : Fuel Clad Mechanical Interaction

FOAK : First Of A Kind

FP : Full Power

FPC : First Pour of Concrete

F.R. : Frequency Rate

FRFCF : Fast Reactor Fuel Cycle Facility

FRP : Fuel Reprocessing Plant

FSAR : Final Safety Analysis Report

FWL : Feed Water Line

GIS : Geographic Information System

GRAPF : Gamma Radiation Processing Facility

GT : Generator Transformer

HDS : Hydrogen Distribution Simulator

HWB : Heavy Water Board

HWP : Heavy Water Plant

HWPSC : Heavy Water Plant Safety Committee

IAEA : International Atomic Energy Agency

ICSD : Ionization Chamber Smoke Detector

ICSP : International Collaborative Standard Problem

ICT : Information & Communication Technology

IFSB : Interim Fuel sub-assembly Storage Building

IGCAR : Indira Gandhi Centre for Atomic Research

IRGD : Industrial Radiation Gauging Devices

IGRED : Industrial Radiography Exposure Device

I.I. : Injury Index

ILRT : Integrated Leak Rate Test

IL : Investigation Level

INES : International Nuclear and Radiological Event Scale

IR : Incident Rate

IREL : Indian Rare Earths Limited

IRRS : Integrated Regulatory Review Service

IRS : Incident Reporting System

IRSN : Institute for Radiological Protection and Nuclear Safety, France

IRV : Instrumented Relief Valve

ISO : International Organisation for Standardization

ISNT : Indian Society for Non-Destructive Testing

IPSD : Industrial Plants Safety Division

ITSD : Information & Technical Services Division

JHA : Job Hazard Analysis

JNPP : Jaitapur Nuclear Power Plant

KAMINI : Kalpakkam Mini Reactor

KAPP : Kakrapar Atomic Power Project

KAPS : Kakrapar Atomic Power Station

KGS : Kaiga Generating Station

KK-CG : KK-Coordination Group

KK-NPP : Kudankulam Nuclear Power Project

LBB : Leak Before Break

LINAC : Linear Accelerator

LOCA : Loss of Coolant Accident

LPIS : Liquid Poison Injection System

LRW : Liquid Radioactive Waste

LWR : Light Water Reactor

MAPS : Madras Atomic Power Station

MCC : Motor Control Centres

MCDA : Multi Criteria Decision Analysis

MCR : Main Control Room

MFBR : Metal-Fuelled Fast Breeder Reactors

MOX	:	Mixed Oxide
MoEF	:	Ministry of Environment & Forests
MoPP	:	Monazite Processing Plant
MSL	:	Main Steam Line
MSLB	:	Main Steam Line Break
MTM	:	Mobile Transfer Machine
MV	:	Motorised Valves
NAPS	:	Narora Atomic Power Station
NC	:	Non-Conformance
NDT	:	Non-Destructive Test
NEA	:	Nuclear Energy Agency
NFC	:	Nuclear Fuel Complex
NMA	:	Near Miss Accidents
NOC	:	No Objection Certificate
NORM	:	Naturally Occurring Radioactive Materials
NPCIL	:	Nuclear Power Corporation of India Limited
NPP	:	Nuclear Power Plant
NPSD	:	Nuclear Projects Safety Division
NSDF	:	Near Surface Disposal Facility
NTC	:	Nuclear Training Centre
NU	:	Natural Uranium
NUOFP	:	New Uranium Oxide and Fabrication Plant
OBE	:	Operating Basis Earthquake
OCDF	:	Orientation Course for DGFS Fellows
OCRP	:	Orientation Course for Regulatory Processes
OEF	:	Operational Experience Feedback
OJT	:	On Job Training
OLIC	:	Official Language Implementation Committee
OPSD	:	Operating Plants Safety Division
OSCOM	:	Orissa Sand Complex
OSEE	:	Off-site Emergency Exercises
PCFPBS	:	Primary Containment Filtration and Pump Back System
PCILRT	:	Primary Containment Integrated Leak Rate Test
PCP	:	Primary Coolant Pumps
PCS	:	Process Controlled System
PCSS	:	Primary Containment Spray System
PDHRS	:	Passive Decay Heat Removal System
PDSC	:	Project Design Safety Committee
PEE	:	Plant Emergency Exercises
PFBR	:	Prototype Fast Breeder Reactor
PHT	:	Primary Heat Transport
PHTS	:	Primary Heat Transport System
PHWR	:	Pressurised Heavy Water Reactor
PRA	:	Probabilistic Reliability Analysis
PRD	:	Personal Radiation Dosimeter
PSA	:	Probabilistic Safety Assessment
PSAR	:	Preliminary Safety Analysis Report
PSR	:	Periodic Safety Review
PSS	:	Primary Shutdown System
QA	:	Quality Assurance
QMS	:	Quality Management System
RAPP	:	Rajasthan Atomic Power Project
RAPPCOF	:	RAPP Cobalt Facility
RAPS	:	Rajasthan Atomic Power Station
RB	:	Reactor Building
RD	:	Rupture Disc
R&D	:	Research and Development
RI	:	Regulatory Inspection
RIA	:	Radio Immuno Assay
ROPP	:	Regional Over Power Protection
RRCAT	:	Raja Ramanna Centre for Advanced Technology
RRC	:	Regional Regulatory Centres
RRE	:	Round Robin Exercise
RRS	:	Reactor Regulating System
RS	:	Remote Sensing
RSD	:	Radiological Safety Division
RSO	:	Radiological Safety Officer
RTI	:	Right to Information
SADD	:	Safety Analysis & Documentation Division

SARCAR : Safety Review Committee for Applications of Radiation

SARCOP : Safety Review Committee for Operating Plants

SAT : Self Assessment Tool

SBO : Station Black Out

SC : Safety Code

SCURF : Safety Committee for Investigation of Unusual Occurrences in Radiation Facilities

SEC : Site Evaluation Committee

SEE : Site Emergency Exercise

SEF : Solar Evaporation Facility

SER : Site Evaluation Report

SER : Significant Event Report

SG : Safety Guide

SG : Steam Generator

SG : Specialists Group

SGDHRS : Safety Grade Decay Heat Removal System

SM : Safety Manual

SMA : Seismic Margin Assessment

SPND : Self Powered Neutron Detector

SPSA : Seismic Probabilistic Safety Analysis

SRI : Safety Research Institute

SR : Severity Rate

SS : Safety Standards

SSA : Site Safety Assessment

SSC : Systems, Structures and Components

SSSC : Seismic Structures Systems and Components

SST : Sea Surface Temperature

TAPS : Tarapur Atomic Power Station

TD : Technical Documents

TDP : Technology Demonstration Plant

TF : Task Force

TG : Turbine Generator

TIR : Thermal Infra Red

Type B (U) : Type B (Unilateral)

UAT : Unit Auxiliary Transformer

UEP : Uranium Extraction Plant

UGC : University Grants Commission

USC : Unit Safety Committee

UCIL : Uranium Corporation of India Limited

USNRC : United States Nuclear Regulatory Commission

VECC : Variable Energy Cyclotron Centre

VRSC : VECC and RRCAT Safety Committee

VSPP : Versatile Solvent Production Plant

VVER : Voda Voda Energy Reactor

WANO : World Association of Nuclear Operators

WG : Working Group

WMCF : Waste Management Centralized Facility

WWER : Water Water Energy Reactor

XRD : X-ray Radiography

ZMT : Zone Mean Temperatures

ZMTD : Zone Mean Temperature Deviation

ZSP : Zirconium Sponge Plant

INTERNATIONAL NUCLEAR AND RADIOLOGICAL EVENT SCALE (INES) (REVISED)

Level/Descriptor	Nature of the Events	Examples
7 MAJOR ACCIDENT	• Major release: Widespread health and environmental effects requiring implementation of planned and extended counter measures.	Chernobyl NPP, USSR(now in Ukraine), 1986
6 SERIOUS ACCIDENT	• Significant release: Likely to require full implementation of planned counter measures.	Kyshtym Reprocessing Plant, Russia,1957
5 ACCIDENT WITH WIDER CONSEQUENCES	• Limited release: Likely to require partial implementation of some planned counter measures • Severe damage to reactor core/Several Deaths from radiation. • Release of large qualities of radioactive material within an installation with a high probability of significant public exposure. This could arise from a major criticality accident or fire	Windscale Pile, UK, 1957 Three Mile Island, NPP, USA, 1979 Goiania, Brazil, 1987
4 ACCIDENT WITH LOCAL CONSEQUENCES	• Minor release of radioactive material unlikely to result in implementation of planned countermeasures other than local food controls. • Fuel melt or damage to fuel resulting in more than 0.1% release of core inventory. • At least one death from radiation/Release of significant quantities of radioactive material within an installation with a high probability of significant public exposure.	Tokaimuro,Japan,1999 Saint-Laurent des Eaux NPP, France, 1980 Fleurus, Belgium, 2006
3 SERIOUS INCIDENT	• Near accident of an NPP with no safety provisions remaining. • Highly radioactive sealed source lost or stolen/misdelivered without adequate radiation procedures in place to handle it. • Exposure rates of more than 1 Sv/hr in an operating area • Severe contamination in an area not expected by design, with a low probability of significant public exposure • Exposure in excess of ten times the statutory annual limit for workers/Non-lethal deterministic health effect (e.g. burns) from radiation	Vandellos NPP, Spain, 1989 Ikitelli, Turkey, 1999. Sellafield,UK,2005 Yanango,Peru,1999
2 INCIDENT	• Significant failures in safety provisions but with no actual consequences • Exposure of member of public in excess of 10mSv/Exposure of a worker in excess of the statutory annual limits/Radiation level in an operating area of more than 50mSv/hr • Significant contamination within the facility into an area not expected by design • Found highly radioactive sealed orphan source, device or transport package with safety provisions intact./Inadequate packaging of highly radioactive material sealed source	Forsmark.Sweden,2006 Atucha,Argentina,2005
1 ANOMALY	• Minor problems in safety components with significant defence in depth remaining/ Low activity lost or stolen radioactive source, device or transport package • Overexposure of member of public in excess of statutory limits	Breach of operating limits at a nuclear facility/Theft of a moisture density gauge
0 DEVIATIONS BELOW SCALE	No safety significance	

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