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GOVERNMENT OF INDIA
ATOMIC ENERGY REGULATORY BOARD
ANNUAL REPORT 2015-16

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, an ex-officio member, four part-time Members and a Secretary.

AERB has a Chairman, an Executive Director and nine divisions. The heads and directors of divisions constitute the Executive Committee which meets periodically with Executive Director, AERB to take decisions on important policy matters related to the management of the Secretariat of the Board. In addition, Safety Research Institute (SRI) was set up at Kalpakkam, to carry out and promote safety related research in areas of relevance to regulatory functions.

AERB has a mechanism to check its effectiveness and quality assurance in its activities and a process by which it improves its systems through its own experience feedback and international regulatory practices. 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 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), Advisory Committee on Security (ACS) 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.

The SARCOP carries out safety surveillance and enforces safety stipulations in the operating units of the DAE under the purview of AERB. 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, radiation and industrial issues from Advisory Committees namely, ACNS, ACRS, ACIFS and ACSD-FCF. ACOH advises AERB on occupational health safety matters.

AERB enforces the following Rules issued under the Atomic Energy Act, 1962:

Atomic Energy (Radiation Protection) Rules, 2004.

Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987.

Atomic Energy (Factories) Rules, 1996.

Atomic Energy (Working of the Mines, Minerals and Handling of Prescribed Substance) Rules, 1984.

The mission of the Board is to ensure that the use of ionizing radiation and nuclear energy in India does not cause undue risk to health of people and environment

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ANNUAL REPORT
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ATOMIC ENERGY REGULATORY BOARD
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MUMBAI-400 094

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FUNCTIONS OF THE ATOMIC ENERGY REGULATORY BOARD

- Develop safety policies in nuclear, radiation and industrial safety areas for facilities under its purview.
- 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.
- Maintain liaison with statutory bodies in the country as well as abroad regarding safety matters.
- Promote research and development efforts in the areas of safety.
- Review the nuclear and industrial safety aspects in nuclear facilities under its purview.
- Review the safety related nuclear security aspects in nuclear facilities under its purview.
- Notifying to the public, the 'nuclear incident', occurring in the nuclear installations in India, as mandated by the Civil Liability for Nuclear Damage Act, 2010.

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HIGHLIGHTS OF AERB ACTIVITIES AT A GLANCE

During the year 2015-16, the Atomic Energy Regulatory Board (AERB) continued to carry out safety monitoring and regulatory supervision of nuclear and radiation facilities under its purview. AERB continued its regulatory safety oversight on Indian operating nuclear power plants (21 units), nuclear power projects (2 under site evaluation, 5 under construction and 1 under commissioning), several fuel cycle facilities, research units and large numbers of radiation facilities spread across the country.

All operating nuclear power plants and fuel cycle facilities under AERB's purview operated safely during the year and radioactive discharges as well as doses to occupational workers were well within prescribed limits. The radioactive releases from NPPs remained well within the limits authorized by AERB and the effective dose to public around the NPP sites was far less than the annual limit of 1 mSv (1000 micro-Sievert) prescribed by AERB. The maximum individual radiation dose among occupational workers has also remained well below the annual limit of 30 mSv prescribed by AERB.

Key Achievements during the year,

- **Completed the development and deployment of the AERB's e-governance initiative for e-Licensing of Radiation Applications 'e-LORA'**
    - More than 35000 X-ray units declared in the system and 23,500 equipment registered
    - Increase in the approval of Radiological Safety officers (RSO)
    - Significantly contributed in reduction of review time
    - AERB received the "SKOCH Smart Governance Award -2015" for e-LORA
- **Licensing/Consent/Review of Nuclear Power Projects**
    - License for regular operation of Kudankulam Nuclear Power Projects Unit-1 (KKNPP Unit - 1) issued for a period of five years
    - Siting consent issued for four units each of 700 MWe PHWR for Gorakhpur Haryana Anu Vidyut Pariyojna, Haryana
    - Consent for Site Excavation issued to KKNPP-3&4, first sub stage of construction clearance
    - Permission for melting of sodium in one of the Secondary Sodium Storage Tank and its recirculation for purification as a part of Pre-commissioning activities for Prototype Fast Breeder Reactor, BHAVINI, Kalpakkam, Tamil Nadu
    - Pre-Consenting design review of Indian Pressurised Water Reactor (IPWR), a (900 MWe /2700 MWt indigenous Pressurised Water Reactor)
- **Renewal of Licenses of operating Nuclear Facilities**
    - Renewal of licenses for operation of Tarapur Atomic Power Stations – 1 & 2, Madras Atomic Power Station, Rajasthan Atomic Power Stations -5&6
    - Renewal of License for operation of Bagjata,Jaduguda Mill and Turamdih Mill of Uranium Corporation of India Ltd.(UCIL), the Heavy Water Plants (HWP) at Manuguru,Kota, Talcher, Baroda and Hazira
- **Conducted nationwide campaign of surprised inspections of Medical diagnostic X-ray Units**

- **Four new Safety Codes and Seven Safety Guidelines/Guides published**, taking to total of more than 156 regulatory documents published by AERB

- **Emergency Preparedness & Response at NPPs**

  - AERB officials witnessed site emergency exercises at six nuclear power stations and offsite emergency exercises at four sites
  - Conducted special regulatory inspections on emergency preparedness aspects
  - Issued guidelines for ensuring harmonization of all EPR plans of NPPs as per AERB Safety Guidelines on "Criteria for Planning, Preparedness and Response for Nuclear or Radiological Emergency"
  - Completed design review of On-Site Emergency Support Centre at NPPs

- **Safety Analysis & Research Development**

  - Independent safety analysis and research on important areas of nuclear and radiation safety to support the regulatory decisions on areas covering Severe Accident (SA) studies, hydrogen distribution & Mitigation studies, reactor physics studies, source term estimation for radiological impact assessment, coupled thermal-hydraulics & structural studies, and probabilistic comparison of risk in Multi-unit NPP sites etc.

- **International Cooperation**

  - Hosted a four-day international workshops on NPPs-SAFETY & SUSTAINABILITY
  - Contributed through participation in international cooperation activities with organizations such as International Atomic Energy Agency (IAEA), Organisation for Economic Cooperation and Development (OECD)/Nuclear Energy Agency (NEA), CANDU Senior Regulator's meeting, the VVER regulators forum, Multinational Design Evaluation Program and bilateral cooperation with international nuclear regulators

- **Public Communication and Information**

  - Implemented mechanism for obtaining comments from the general public on Safety Codes
  - 12 Press releases were issued on the different topical issues
  - Regular updates were provided during KAPS Unit-1 PT leak incident
  - 9 awareness programs on radiation safety covering a wide target audience
  - 3 exhibitions in Science and Technology fairs
  - Advertisements in print media to sensitize the users on requirements of AERB for use of medical x-ray equipment as well as for users of radioactive sources or radiation generating equipment

- **Human Resources Development**

  - Augmentation of manpower and competency enhancement through competency mapping
  - On-Job training of AERB Officers at sites
  - Two senior officers from AERB were deputed for a one year assignment to the US Nuclear Regulatory Commission (NRC) under bilateral exchange of technical information and cooperation in nuclear safety matters
  - Provided training on 'Regulatory Framework for Nuclear Power Plants and Fuel Cycle Facilities' for officials from various Nuclear Organizations of Bangladesh.

COMPOSITION OF THE BOARD

Chairman, AERB

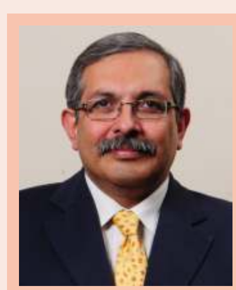
Shri S.A. Bhardwaj

Members

Shri D.K. Shukla
Ex-Officio AERB Member
Chairman, SARCOP

Dr. K. V. Raghavan
Distinguished Professor,
INAE, Indian Institute of Chemical Technology,
Hyderabad

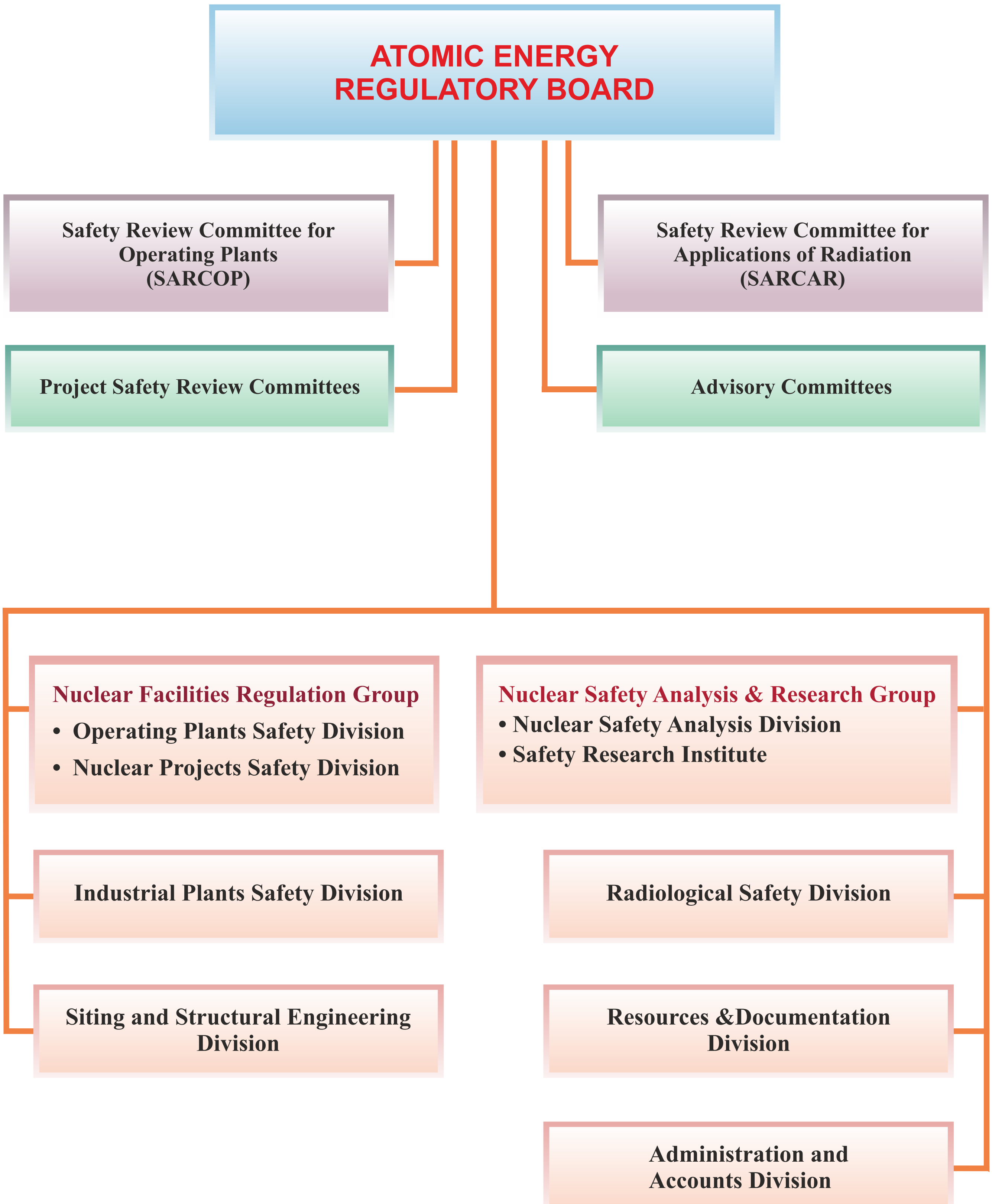
Dr. Harsh K. Gupta
President IUGG,
National Geophysical
Research Institute,
Hyderabad



Prof. Devang V. Khakhar
Director,
Indian Institute of Technology,
Bombay

Dr. G.K.Rath
Professor and Head
Department of Oncology, AIIMS,
New Delhi

ORGANISATION CHART OF AERB



CHAPTER 1

SUMMARY

During the year 2015-16, the Atomic Energy Regulatory Board (AERB) continued to carry out its principal mandate of monitoring the safety of all facilities and activities involved in nuclear energy and applications of ionizing radiations that are under its purview. AERB continued the regulatory activities in its endeavor to achieve its mission and to strengthen itself as a more effective and efficient regulator.

AERB continues its regulatory supervision of the nuclear power plants, front-end and back- end nuclear fuel cycle facilities, research facilities under its purview and the radiation facilities which are involved in applications of ionizing radiation in industry, medicine, agriculture & research.

AERB carried out its functions with the support of its secretariat and specialist committees under the guidance of the Board. The Board met three times during the year and reviewed the safety status of operating Nuclear Power Plants (NPPs), Nuclear Power Projects under construction / commissioning, Nuclear Fuel Cycle Facilities & Radiation Facilities. Based on satisfactory review, the important decisions taken by the Board were as follows:

AERB Board Meeting in Progress

1. Issue of License for regular operation of KKNPP Unit -1 for a period of five years (up to July 2020)
2. Issue of Siting consent for Gorakhpur Haryana Anu Vidyut Pariyojna Unit 1 to 4, Haryana.
3. Approval for the publication of the following Safety Codes related to Medical, Industrial, Agriculture and Research Applications and Transport of Radioactive Material,
   - Safety Code on Industrial Radiography,
   - Safety Code on Radiation Processing Facilities
   - Safety Code Radiation Safety in Manufacture, Supply and Use of Medical Diagnostic X-ray Equipment
   - Safety Code on Safe Transport of Radioactive Material

Safety Surveillance of Nuclear and Radiation Facilities

All Nuclear Power Plants (NPPs) in operation and under construction, nuclear fuel cycle facilities and radiation facilities undergo in depth safety reviews by AERB during various stages namely siting, construction, commissioning and operation, as relevant. AERB issues regulatory consents for siting, construction, commissioning, operation and decommissioning, as applicable, based on requisite safety reviews and assessments. During the operational phase of the facilities, AERB monitors safety of the facilities and activities through periodic regulatory inspections, review of the specified periodic reports, and comprehensive safety reviews as part of periodic renewal of licenses. AERB follows well established processes for regulatory inspections, safety reviews (multi-tier) and assessment of the facilities and activities. AERB also carries out research & development activities and safety analysis in support of its regulatory functions.

Safety Surveillance of Nuclear Power Projects under construction

During the year, AERB issued License for regular operation of Unit -1 of Kudankulam Nuclear Power Plant (KKNPP-1) after satisfactory completion of the requisite commissioning tests and steady operation of the unit at the rated power for the specified period.

Unit 2 of the Kudankulam Nuclear Power Plant (KKNPP-2) is under commissioning. During 2015-16, AERB issued clearance for Hot-Run of the unit. AERB reviewed the results of the Hot-Run, the pre-service inspections of important equipment and systems and status of the compliance to the recommendations and stipulations of AERB. AERB also took up review of the applications for Initial Fuel loading (IFL) and First Approach to Criticality (FAC) of the Unit-2 of KKNPP.

(After satisfactory resolution of various issues related to these, AERB issued clearances for IFL and FAC on May 24, 2016 and June 27,2016 respectively. The unit achieved criticality on July 10, 2016).

AERB had earlier issued the Siting Consent for Units 3 & 4 of Kudankulam Nuclear Power Project (KKNPP-3 & 4), 1000 MWe VVER type reactors of similar design as KKNPP -1 &2, in February, 2011. After satisfactory completion of the review of relevant aspects, AERB issued the clearance for Site Excavation of KKNPP-3&4, which is the first sub stage of construction clearance.

After satisfactory completion of review of Site Evaluation Report and associated submissions, AERB issued the Siting Consent for four units of 700 MWe PHWRs (GHAVP-1 to 4) at Gorakhpur in July, 2015. Review of the application for construction consent for the first two units is in progress.

Four units of 700 MWe PHWR are under construction, two each at Kakrapar and Rajasthan sites. The AERB had issued clearances for erection of Major Equipment in these units during the year 2014 and 2015, respectively. Currently, AERB is reviewing the safety aspects with respect to design of these projects according to the relevant sub stages of construction clearances as well as compliance to the relevant codes & standards, and recommendations /stipulations of AERB in the construction consents.

The 500 MWe Prototype Fast Breeder Reactor (PFBR) is undergoing preparations for taking up commissioning activities. AERB has been reviewing the preparedness of PFBR project for taking up of commissioning activities and safety review of the commissioning procedures

AERB is currently reviewing the Application and other related submissions with respect to Siting Consent for six units of Evolutionary Pressurised Reactor (EPR) each of 1650 MWe proposed to be setup at Jaitapur, Maharashtra and the Application seeking Siting Consent for the proposed FBR-1&2 that is proposed to be set up at Kalpakkam in Tamil Nadu.

The Bhabha Atomic Research Centre (BARC), jointly with NPCIL, is developing the design of Indian

Installation of Pre Service Inspection (PSI) fixture for Reactor Pressure Vessel (RPV) Inspection in KKNPP-Unit # 2

Bird Eye view of KAPP 3 & 4 Project Site

Bird Eye view of RAPP-7 & 8 Project Site

Pre-Commissioning activities in progress at PFBR site

Pressurised Water Reactor (IPWR). IPWR is an indigenous PWR design with a power rating of 2700 MWt – 900 MWe, incorporating advanced safety features, including passive safety systems similar to the ones developed for the Advanced Heavy Water Reactor (AHWR). The IPWR also incorporates layout features of the 700 MWe PHWRs being constructed in India. AERB has taken up pre-consenting review of the design of IPWR. In this regard, AERB has reviewed the technical design document (TDD) of IPWR based on the request from BARC.

The details of safety surveillance of Nuclear Power Projects during the year 2015-16 are given in Section 2.1 of Chapter-2.

Safety Surveillance of Nuclear Power Plants in Operation

There are twenty one nuclear power plants in operations. AERB continued its regulatory supervision of these plants. The radioactivity releases from all the nuclear power plants were below the limits specified in the technical specifications for operation. Effective dose to public in the vicinity of NPP sites was far less than the annual limit of 1 mSv (1000 micro-Sievert) prescribed by AERB. Public dose limit of 1000 micro-Sv per year is an International benchmark, based on the recommendation of International Commission on Radiological

The radioactivity releases from all the nuclear power plants were below the limits specified in the technical specifications for operation.

Effective dose to public in the vicinity of NPP sites was far less than the annual limit of 1 mSv (1000 micro-Sievert) prescribed by AERB.

Protection (ICRP). The radiation exposure to occupational workers in these plants was also well below the prescribed limit of 30 mSv in a year, with maximum individual radiation dose as 18.71 mSv. AERB dose limit of 30 mSv in a year for the occupational workers is more conservative as compared to the ICRP recommended limit of 50 mSv in a year.

On March 11, 2016, there was an incident of leakage from a coolant channel at KAPS Unit-1. Following the leak from primary coolant system; the reactor underwent an automatic shutdown. The safety systems, viz. emergency core cooling and containment isolation got actuated and performed as intended. Following the event, plant emergency was declared, which was terminated after safely discharging the fuel from the leaky channel and isolating this channel from the primary coolant system on March 21, 2016. There was no fuel failure. The event did not result in any radiation over-exposure to plant personnel. The radioactivity releases were within the specified limits for normal operation. During the course of the plant emergency, the environmental surveillance carried out within the site, as well as in the off-site domain up to 30-km from the plant, confirmed that there was no increase in the background radiation levels and there was no radioactive contamination. Currently, the unit is under shutdown for investigations. Based on the incident, AERB has stipulated expeditious inspection of coolant channels in all other operating reactors as well as thorough review of design and leak detection capability of Annulus Gas Monitoring System (AGMS) to detect any vulnerability of such events in other operating units.

As a part of the operating experience feedback programme, all the NPPs are required to carry out investigations of various events occurring in the plant (significant events) for identifying the root causes, so as to take corrective actions to obviate recurrence of such events. Reports on such events and the investigations and corrective actions are required to be reported to AERB as per the specified reporting criteria. These reports are reviewed in detail in AERB to see the adequacy of investigations, corrective actions, lessons learned and the need for any regulatory actions. During the calendar year 2015, there were 42 significant events reported from the operating NPPs. The events are also rated as per the International Nuclear and Radiological Event Scale (INES) which rates the events on a scale of 1-7,based on the their consequences. All the events were of INES level-0(corresponding to deviations below scale).The event of leakage from a coolant channel at Unit-1 of Kakrapar Atomic Power Station (KAPS -1) which took place on March 11, 2016 was provisionally rated as Level-1 (corresponding to Anomaly). The event is under investigation.

During the year, AERB reviewed the applications for renewal of license for operation of TAPS-1&2, MAPS and RAPS-5&6 and the license for operation of these reactors were extended.

Site Emergency Exercises were conducted at all NPP sites and Off-Site Emergency Exercises were conducted at Tarapur, Kalpakkam, Narora and Kaiga site. AERB officials carried out special regulatory inspections on emergency aspects and participated in these emergency exercises as observers. AERB also participated in emergency exercises conducted by IAEA under the 'Convention on Early Notification of Nuclear Accident and Convention on assistance in Nuclear Accident or Radiological Emergency'.

The details of safety surveillance of operating Nuclear Power Plants during the year 2015-16 are given in Section 2.2 of Chapter-2.
The Status of Environmental Safety and Occupational Exposures are given in Chapter 5.
The Status of Emergency Preparedness of the Nuclear Facilities is given in Chapter 6.

Safety Surveillance of other Nuclear Facilities

During the year, AERB continued to review the safety aspects of the Nuclear Fuel Cycle and Research & Development (R&D) facilities under its purview. These facilities include the atomic minerals exploration units of Atomic Minerals Directorate for Exploration and Research (AMD) facilities, mines & uranium ore processing mills of Uranium Corporation of India Ltd. (UCIL), thorium mining, mineral separation plants & mills of Indian Rare Earths Ltd. (IREL), Nuclear Fuel Complex (NFC) at Hyderabad, Zirconium Complex (ZC) at Pazhayakayal, Heavy Water Plants (HWP), diversified projects of Heavy Water Board, R&D units at Variable Energy Cyclotron Centre (VECC), Raja Ramanna Centre for Advanced Technology (RRCAT) and industrial units of Electronics Corporation of India Limited (ECIL).In addition, AERB also reviewed the radiological safety aspects in the facilities handling Beach Sand Minerals (BSM) and other Naturally Occurring Radioactive Materials(NORM).

AERB issued/renewed License for operation of Bagjata, Jaduguda Mill and Turamdih Mill of Uranium Corporation of India Ltd. (UCIL), the Heavy Water Plants (HWP) at Manuguru, Kota, Baroda, Hazira and

various plants operational at HWP-Talcher. AERB has also issued the License for regular operation of INDUS-2 Accelerator (2.5 GeV, 200mA) at RRCAT- Indore, plants of Electronics Corporation of India Ltd (ECIL), Hyderabad.

The back end nuclear fuel cycle facilities namely, Demonstration Fast Reactor Fuel Reprocessing Plant (DFRP) and Fast Reactor Fuel Cycle Facility (FRFCF) at IGCAR, Kalpakkam, Tamil Nadu are under construction. AERB is reviewing the design safety aspects of these facilities with respect to clearances for relevant stages of construction. AERB is also reviewing an Application for Construction Consent for a demonstration facility for Metallic Fuel Fabrication (DFMF) that is proposed to be set at IGCAR, Kalpakkam, Tamil Nadu.

AERB also reviewed and issued consent /clearance for various research facilities at Indira Gandhi Centre for Atomic Research (IGCAR) and facilities of Board of Radiation and Isotope Technology (BRIT).

The details of safety surveillance of these Facilities during the year 2015-16 are given in relevant sections of Chapter-2.
The Status of Environmental Safety and Occupational Exposures are given in Chapter 5.
The Status of Emergency Preparedness of the Nuclear Facilities is given in Chapter 6.

Safety Surveillance of Radiation Facilities

AERB carried out safety review of various facilities using radiation sources in industry, medicine, agriculture and research. During the period, AERB issued 14092 consents for operation (license, authorization and registration), 167 type approvals, 2862 approval of radiation safety officers for different practices and 2829 permissions for procurement of radioactive sources (imported & indigenously manufactured).

During the year, AERB carried out 759 regulatory inspections covering the radiation facilities. AERB carries out inspection of radiation facilities in accordance with graded approach based on the radiological hazard potential.

> As part of its e-Governance initiatives, AERB has completed the development phase of e-LORA on December 31, 2015.Around 35, 000 X-ray equipment has been declared in the e-LORA system of which, around 23,500 equipment are licensed.

As part of its e-Governance initiatives, and with the objective to enhance the efficiency and transparency in the regulatory processes, AERB has put into operation a web-based system called "e-Licensing of Radiation Applications (e-LORA)" which enables automation of the regulatory processes for various Radiation Facilities located across the country. AERB has completed the development phase of e-LORA on December 31, 2015. With the e-LORA fully functional, AERB today has a user friendly interface for the applicants and licensees with AERB. The automation has also helped AERB in disposition of the applications at a much shorter time interval in comparison to earlier practice. Around 35,000 X-ray equipment has been declared in the e-LORA system of which, around 23,500 equipment are licensed. In recognition of this initiative, AERB received the “SKOCH Smart Governance Award - 2015”.

With several other initiatives along with e-LORA, AERB has strengthened its regulation of diagnostic X-ray equipment and have resulted into a significant increase in regulation of these equipment. As a part of the nation-wide campaign taken up by AERB to ensure increased compliance and regulatory coverage of Medical diagnostic X-ray equipment, AERB carried out surprised inspection of these facilities in major cities/towns in the country and suspended operation of some of the medical diagnostic facilities in view of their non-compliance with the specified regulatory & radiation safety requirements.

incident is being closely monitored by AERB. AERB has issued show-cause notice to the concerned industrial radiography institution for committing violations of stipulated regulatory provisions and lack of physical security measures provided for radiography exposure devices during storage.

AERB continues to reinforce its regulatory inspections at institutions possessing disused sources, to ensure the safety of source while at the same time ensuring that the security arrangements at these institutions remain appropriate.

Following certain news reports regarding use of dental X-ray examinations with the aim of age determination or birth registration, AERB issued an advisory to medical/dental fraternity and the general public against indiscriminate use of dental x-ray examinations solely for the purpose of non-diagnostic applications such as age determination or birth registration.

The details of safety surveillance of these Facilities during the year 2015-16 are given in Chapter-3.
The Status of Occupational Exposures and Environmental Safety are given in Chapter 5.

During the year, AERB has signed MoU with the Government of West Bengal for establishment of Directorate of Radiation Safety (DRS). The objective underlying the setting-up of the State-level DRS is to strengthen the safety regulatory control over medical diagnostic X-ray facilities in view of the large number of diagnostic X-ray units/facilities spread across the country and the accelerated growth in their numbers. As on date, AERB has signed agreements with of 13 States and presently DRS are authorised to carry out regulatory inspections of diagnostic radiology facilities in the States of Kerala, Chhattisgarh, Arunachal Pradesh, Mizoram, Punjab and Tripura.

An incident involving theft of two numbers of industrial gamma radiography exposure devices (IGREDs) was reported from an industrial radiography inspection facility at, New Delhi. The incident was reported to AERB after two days of noticing the theft and is under investigation by the Law & Enforcement Authority of Sarita Vihar, New Delhi. The above theft

Industrial Safety

AERB is responsible for administration of the Factories Act, 1948 and the Atomic Energy (Factories) Rules, 1996 in all the units of DAE under its purview. In this regard, AERB discharges its regulatory functions identified under the Factories Act, 1948 for these facilities, including issuance of Licenses, review of industrial and fire safety aspects, authorizing Competent Persons, Certifying Surgeons, conduct of inspections to verify compliance to the specified safety requirements etc. AERB also reviews the construction safety aspects of nuclear projects by carrying out inspections of the facilities under construction.

During the year 2015-16, four fatalities of construction workers were reported from IGCAR, Kalpakkam, RAPP 7&8 Project site, Rawatbhatta and from NFC, Hyderabad. All these accidents were investigated and reviewed in AERB. Based on these reviews, AERB stipulated additional measures for strengthening safety management and supervision of the construction sites. AERB took enforcement actions of stopping the construction activities at these sites till the site implemented the recommendations made by AERB and put in place the required safety management systems and supervision. Based on the submission of compliance reports and review by the sites, AERB carried out a special inspection at these sites, before permitting resumption of construction activities. The lessons learnt from these incidents were disseminated to all DAE units.

The details of monitoring of Industrial safety status in DAE units during the year 2015-16 are given in Chapter-4.

Safety Document Preparation

During the year, eleven new regulatory safety documents were published, out of which four were Safety Codes and seven Safety Guides/Guidelines. Six regulatory safety documents were under development and four were translated into Hindi. As of now, AERB has published 156 regulatory safety documents for nuclear and radiation facilities including industrial safety.

AERB has now established a mechanism for obtaining comments from the general public on Safety Codes. From October 2015 onwards, the draft safety codes are being posted on the website of AERB for public comments.

As of now, AERB has published 156 regulatory safety documents for nuclear and radiation facilities including industrial safety.

Draft Safety Codes are posted on the AERB's website for Public Comments

Research & Development (R & D) and Safety Studies

AERB carries out independent safety analysis and research on important areas of nuclear and radiation safety which facilitate the regulatory review and constitute one of the inputs for regulatory decision making during licensing process. During the year, AERB had focused on areas covering Severe Accident (SA) studies for PHWR and VVER, hydrogen distribution & Mitigation studies, reactor physics studies, source term estimation for radiological impact assessment, environmental safety, coupled thermal-hydraulics & structural studies, and probabilistic comparison of risk in Multi-unit NPP sites. AERB also participated and contributed in various internal collaborative exercises aimed at new knowledge development.

AERB continued to promote and fund several research projects on reactor safety, radiation safety, front end and back end fuel cycle safety related problems and industrial safety at various reputed universities and academic institutions under the Safety Research Programme. During the period six new projects were approved and twelve on-going projects were renewed.

The details of various activities of safety analysis and research are presented in Chapter-8.

International Cooperation

During the year, AERB took several initiatives to enhance its contribution in harmonization of international regulatory practices and methodologies. AERB continued its participation in international cooperation activities with organizations such as International Atomic Energy Agency (IAEA), Organisation for Economic Cooperation and Development (OECD)/Nuclear Energy Agency (NEA), CANDU Senior Regulator's meeting, the VVER regulators forum and Multinational Design Evaluation Program.

AERB successfully hosted a four-day international workshop on NPPs -SAFETY & SUSTAINABILITY, combining the international Workshops CANSAS-2015 (CANDU Safety Association for Sustainability) & IW-NHNRTHS-2015 (International Workshop on New Horizons in Nuclear Reactor Thermal Hydraulics Safety) during December 8-11, 2015. AERB also hosted the 14th AERB-USNRC bilateral meeting and workshop at Mumbai during October 27-29, 2015. As a full member of the Multinational Design Evaluation Program (MDEP), AERB actively participated and contributed in the deliberations and activities.

AERB signed an arrangement for regulatory cooperation with Canadian Nuclear Safety Commission (the nuclear regulatory authority of Canada). AERB already has bilateral arrangements with the regulatory bodies of other countries namely, France, Russia, Romania, Ukraine, the United States of America and Finland.

India is a contracting Party to the Convention on

Nuclear Safety (CNS). AERB led the Indian Delegation to the Organizational Meeting of the CNS, in preparation of the Indian participation in the forthcoming 7th Review Meeting of CNS.

Details on AERB's contribution in various international forum are presented in Chaper-10.

Human Resource Development

Availability of adequate number of competent staff and maintaining the competence for current and future needs of AERB is important for efficient and effective discharge of its mandate. AERB has augmented the technical manpower substantially by inducting post-graduates through AERB Graduate Fellowship scheme (AGFS) in IIT Bombay and IIT Madras and through training schools of BARC, IGCAR and NFC and transfer of experienced personnel from operating plants and R&D institutes. During the period, the scientific & technical manpower in AERB has increased from 251 to 264. The total strength of manpower in AERB is 326.

For effective management of competency of AERB staff, competency mapping analysis was carried out for AERB Officers. Based on the outcome of the gap analysis, training programmes has been initiated to bridge the gaps. In addition, AERB continued to train its staff by organizing various training programmes, workshops, on the job training at NPP sites etc. Three officers of AERB have achieved higher qualifications in the areas of engineering. AERB officials also acted as faculty members in various national and international training programs.

Under bilateral exchange of technical information and cooperation in nuclear safety matters with the US Nuclear Regulatory Commission (USNRC), AERB deputed two officers for a one year assignment to the USNRC. The above assignment provided a unique opportunity for the officers to experience the functioning of the NRC with regard to regulation of operating NPPs and NPPs under construction by interacting with the staff of the NRC on daily basis & participating in their activities.

To promote excellence and recognize outstanding achievements of the staff engaged in the AERB regulatory and associated research & development activities, AERB has instituted a yearly award scheme from the year 2012. AERB award scheme comprises of individual awards as well as group achievement awards. Awards for the year 2014-15 were distributed during the Annual Day Celebrations of AERB held on November 16, 2015.

Public Outreach Activities

AERB has the mandate to keep the public informed on major issues of radiological safety significance. AERB provides all necessary information to its stakeholders through its periodic newsletters, annual reports, annual bulletin, website, press releases/ briefings etc. The AERB annual reports, contain information on safety status of nuclear & radiation facilities and findings of regulatory reviews. It also includes information on safety significant events reported by licensee and the regulatory inspections. AERB website plays a pivotal role in keeping the public informed on issues related to radiological safety, major regulatory decisions and special technical reports etc. The AERB Bulletin, which is the popular version of the Annual Report of AERB, presents the most important activities in a more understandable and public friendly format.

AERB sought the views/ comments from public and other interested parties on the draft of the newly developed safety codes towards assessing the effectiveness of such process.

Information on operating nuclear power plants including, validity of operating license, Regulatory Inspections, Significant Events, radioactive effluent discharges, occupational exposures, rated power capacities of all operating NPPs etc are provided on the AERB's website and are updated on quarterly basis.

During the year, 12 Press releases were issued on the different topical issues including; License for Regular Operation of Kudankulum NPP Unit -1, Consent for Siting of four more Indigenous Nuclear Power Units in Haryana, enforcement actions taken by AERB during surprise inspection campaign at various medical diagnostic facilities in the major cities/towns in India, release of e-LORA modules and on incident of leak from one of the coolant channel occurred at Kakrapara Atomic Power Station (KAPS) Unit -1.

Subsequent to the incident of leak from one of the coolant channel at KAPS-1, AERB promptly issued a press release on the safety status of the plant and functioning of respective safety systems. Thereafter, AERB kept the public/media engaged by issuing updates on the incident through its website. The proactive steps taken by AERB for communicating the safety status paved way for fruitful interaction between media and AERB and helped to a large extent in allaying the apprehensions of fear and rumors among public.

Nine awareness programs focusing on the aspects of enhancing radiation safety awareness were conducted for target audience including the radiation workers, manufacturers/ suppliers of equipment, personnel from the industry, university faculty and students

AERB continued strengthening its public outreach activity with an aim to reach out to all sections of society (public, stakeholders, including manufacturers & suppliers, operator etc.) and bring awareness on the aspects of nuclear, radiation & industrial safety. Nine awareness programs focusing on the aspects of enhancing radiation safety awareness were conducted for target audience including the radiation workers, manufacturers/ suppliers of equipment, personnel from the industry, university faculty and students.

AERB published advertisements in print media on aspects of obtaining requisite consents for possessing or use of radioactive sources/radiation generating equipment and requirements for medical diagnostic X-ray units. AERB also participated in some of the science and technology fairs for displaying exhibits on the safety and regulatory aspects of Nuclear & Radiation Facilities.

Apart from above mentioned activities, AERB timely provided response to the parliament questions and on queries posted by the members of public under the "Right to Information Act", 2005 enacted by the Parliament of Government of India.

Chapter 2 Safety Surveillance Of Nuclear Facilities

2.1 SAFETY REVIEW MECHANISM OF NUCLEAR FACILITIES

Nuclear facilities in India are sited, designed, constructed, commissioned and operated in accordance with strict quality and safety standards. Atomic Energy Regulatory Board (AERB) oversees the safety of the nuclear and radiation facilities and has been mandated to frame safety policies, lay down safety standards and requirements. AERB has established a regulatory framework, which involves stipulating the safety requirements, issuance of regulatory consents, verification of compliance through safety reviews & inspections during various stages namely siting, design, construction, commissioning, operation etc.

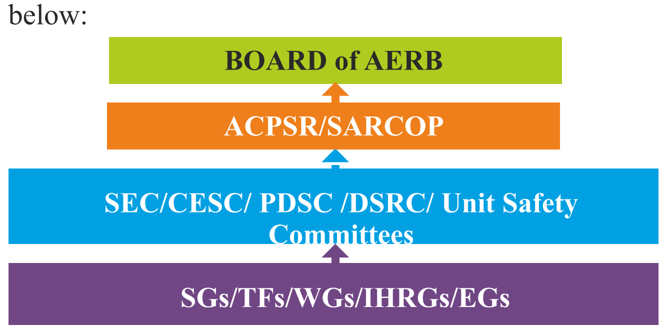
All Nuclear facilities undergo an elaborate and in-depth safety review during various stages. The objectives of safety reviews and assessment at various consenting stages is illustrated below:

Siting	the chosen site meets the Site Evaluation Criteria and is suitable for the proposed type and capacity of the plant from environmental considerations
Construction	the proposed plant design and the applicant's statements and commitments meet the regulatory requirements, the proposed construction meets quality requirements
Commissioning	the test program and procedures are consistent with requirements, the performance of the plant is as per design intent, the results of tests confirm the adequacy of the design for regular operation of the plant, safety analysis for the as-built facility has been carried out to meet the regulatory requirements
Operation	the operational limits and conditions are consistent with regulatory requirements and an adequate level of safety is maintained during operation, through proper operational and maintenance procedures and administrative control, organisational structures, training and qualification of operating personnel meet the requirements, and conditions for renewal of consent as prescribed by AERB.

The safety reviews related to the consenting decisions and safety monitoring during various stages are carried out through multi-tier system of safety committees. The committees include experts in a host of relevant fields, including process design, control & instrumentation, thermal hydraulics, structural analysis, reactor physics, seismology etc, relevant to nuclear and radiation safety. The higher level committees include experts from academia, national R&D institutes, and government bodies. The multi-tiered system of safety reviews follows the principle of "management by exception", following graded approach and is based on principles, requirements and criteria specified by AERB in its regulatory documents.

In this approach, the issues of greater significance are given consideration at higher level committees for their satisfactory resolution. Recommendations of these committees concerning the various safety issues and consents are further considered by AERB for arriving at regulatory decisions. This arrangement ensures comprehensiveness of the reviews and checks compliance with the specified requirements. Additionally, the staff of AERB carries out periodic regulatory inspections to check conformance with regulatory norms and consenting conditions.

A typical multi-tier review system followed at various consenting stages for nuclear facilities is shown below:



- AERB : Atomic Energy Regulatory Board
- ACPSR : Advisory Committee for Project Safety Review
- PDSC : Project Design Safety Committee
- SEC : Site Evaluation Committee
- CESC : Civil Engineering Safety Committee
- DSRC : Design Safety Review Committee
- SG : Specialist Groups
- WG : Working Group
- TF : Task Force
- EG : Expert Group
- IHRG : In-House Review Groups

The license for operation of the facilities is given after ensuring satisfactory construction and commissioning as per the approved design, complying with the quality requirements and the specified safety/regulatory requirements. The license for operation is given for a maximum validity period of five years. Renewal of license for operation is considered based on separate application along with a comprehensive safety review as per the laid down requirements and process.

In the case of operating NPPs, there is requirement for carrying out a comprehensive periodic safety review (PSR) once in ten years, as per the laid down requirements. The PSR involves a thorough assessment of the safety of the plant in comparison with the current safety requirements and practices, covering a number of identified safety factors. The PSR facilitates a cumulative assessment of plant ageing, modifications, safety performance, advances in science and technology and feedback of operating experience. The PSR provides opportunities for identifying and implementing safety upgrades/enhancements in the plants as well as the regulatory programmes, as necessary. This regulatory approach ensures that the safety levels of the plants are maintained and enhanced to remain comparable with the contemporary safety standards /practices throughout the operating life of the plant.

Besides safety review of nuclear facilities, the physical protection systems for security of systems affecting safety of nuclear facilities are also reviewed during the stage wise consenting process and verified during operations.

2.2 MANAGEMENT SYSTEM OF AERB

In order to meet the required standard and continual improvement of quality in carrying out its functions, AERB has been certified under ISO 9001 standard by the Bureau of Indian Standards (BIS) since November 15, 2006. AERB has implemented Quality Management System (QMS) under ISO 9001:2008 for its core regulatory processes viz, for its consenting activities, regulatory inspections and preparation of regulatory documents. This Quality Management System is developed based on experience over the years on regulation of nuclear and radiation facilities in the country, its policy and regulatory documents, IAEA and other international standards. The QMS integrates various functions and responsibilities towards realizing the safety goal of AERB. During the period, the documents of Level-I (Quality Manual) & Level –II (QMS Procedures) have been revised and the Quality Management System (QMS) of AERB was re-certified by BIS as per new ISO 9001: 2008.

Additionally, AERB has documented an Integrated Management System (IMS) in line with IAEA Safety Standard GSR-3 encompassing existing management system for core regulatory processes and other activities undertaken by AERB. This system integrates various functions and responsibilities towards realizing the safety goal of AERB. A number of procedures have been developed and are being implemented in a phased manner. Management System of AERB emphasizes Safety as paramount, overriding all other demands.

The safety status of the nuclear facilities under the purview of AERB and the important outcome of safety reviews and assessments during the period 2015-2016 are given in the following sections.

2.3 NUCLEAR FACILITIES UNDER CONSTRUCTION

AERB has established an elaborate system for in-depth safety review of Nuclear Power Projects and fuel cycle facilities that are under construction. For this purpose, different stages of 'regulatory consent' have been identified as following:

- Siting
- Construction
- Commissioning

During 2015-16, status of various nuclear power projects under review by AERB is presented in Table 2.1 and under construction fuel cycle facilities is presented in Table 2.2.

The information on the meetings of the important safety review committees of facilities undergoing reviews related to siting / construction / commissioning is given in Table 2.3.

Important outcome of the safety reviews and assessments related to nuclear power projects and fuel cycle facilities are given in subsequent paragraphs.

(A) NUCLEAR POWER PROJECTS UNDER CONSTRUCTION: REVIEW STATUS

Safety review activities related to the Nuclear Power Projects (refer Table 2.1) continued during the year.

Table 2.3: Meetings of the important Safety Review Committees of facilities undergoing reviews related to siting/construction/commissioning during the year 2015-16 *(following reviews conducted by Experts Group/Specialists Groups/Working Groups/Task Forces/In-house Review Groups etc.)*

Project Safety Committee	Number of Meetings
ACPSR – LWR-1	13
ACPSR – LWR-2	NIL
ACPSR – PHWR/PFBR	2
ACPSR – FRFCF & DFRP	NIL
ACPSR-FCF	1
PDSC–KAPP-3,4 & RAPP-7,8 & GHAVP-1,2	7
PDSC –KKNPP- 3&4	4
PDSC–PFBR	7
PDSC–FRFCF &DFRP	1
DSRC –NFC	3
DSRC-DP	1
DSRC-UEP	2
SEC -JNPP	1
SEC - GHAVP	5
SEC -FBR-1&2	1
CESC	8

A.1 Light Water Reactor based NPPs

(i) Kudankulam Nuclear Power Project (KKNPP) Unit – 1

Subsequent to completion of commissioning activities and satisfactory review of Application for License for Operation, AERB issued the license for operation of KKNPP-1 on July 10, 2015. The license is valid till June 2020.

The unit was shut down on June 24, 2015 for refuelling, inspection and maintenance activities. The unit was restarted after satisfactory completion of all refueling activities on January 21, 2016. The unit was thereafter operational up to its rated capacity.

During the course of commissioning activities, AERB had posted its independent observer teams (AOTs) at KKNPP Unit-1 Site for physical verification of compliances to the requirements and recommendations made by AERB. The reports of the AOT were regularly reviewed for necessary follow up.

As part of post Fukushima safety re-assessment, NPCIL had conservatively estimated the ultimate load bearing capacity (ULBC) of the reactor containment. It was seen that the containment will have adequate margins to remain functional even in case of pressures exceeding twice the design pressure of the containment. The details of the assessment were reviewed by AERB and found to be acceptable.

(ii) Kudankulam Nuclear Power Project (KKNPP) Unit – 2

As part of commissioning activities, 'Hot Run' was completed successfully in May 2015. Thereafter, the reactor vessel was opened and various pre-service inspections (PSI) were carried out which included inspection of the reactor pressure vessel and its internals, steam generators, main coolant pipelines, passive heat removal system, heat exchangers and pipelines of other safety systems. AERB reviewed the results of commissioning tests and PSI findings.

During the course of commissioning activities, AERB had posted its independent observer teams (AOTs) at KKNPP Site for physical verification of compliances to the requirements and recommendations made by AERB as well as to witness various commissioning tests. The reports of the AOT were regularly reviewed for necessary follow up.

The observations made following the hot run indicated that, a cover bolt of the locking nut of impeller of one of the coolant pumps became loose and got detached. The issue was investigated for establishing the root cause. Based on the investigation and the safety review, modifications were implemented in the design of the locking mechanism of the component in KKNPP Unit-2. Based on this feedback, modifications were also incorporated in pumps of KKNPP Unit -1 during the refueling shutdown period.

The design of KKNPP uses many advanced safety features including passive systems / equipment as multiple backup to the front line safety systems. One such component, a Double Check Valve (DCV), a part of

Table - 2.1: Status of various Nuclear Power Projects under review by AERB

Project Stage	Project	District / State	Utility/ Licensee/ Applicant	Type	Review Status
Site evaluation	Gorakhpur Haryana Anu Vidyut Pariyojana-GHAVP 1-4, Gorakhpur	Fatehabad/ Haryana	NPCIL	700 MWe PHWRs each, of indigenous design	• Siting consent issued in July 2015 • Review of application for site excavation consent is under progress
	Jaitapur Nuclear Power Project (JNPP)-1-6, Ratnagiri	Ratnagiri/ Maharashtra	NPCIL	1650 MWe EPR (light water reactor) each, of French Design	• Site Evaluation is in progress
	FBR 1&2, Kalpakkam	Kancheepuram/, Tamilnadu	Bhartiya Vidyut Nigam (BHAVINI)	500 MWe Fast Breeder reactor each of indigenously design	• Site Evaluation is in progress
Construction	Kudankulam Nuclear Power Project - KKNPP 3-6, Kudankulam	Tirunelveli, Tamilnadu	NPCIL	1000 MWe VVER (light water reactor) each, of Russian Design	• Siting consent issued in 2011 • Clearance for site excavation (first stage of construction consent) was issued in January 2016 • Reviews related to application for construction consent was in progress
	KAPP 3&4, Kakrapar	Tapi, Gujarat	NPCIL	700 MWe PHWRs each, of indigenous design	• Clearance for Major Equipment Erection (last stage of construction consent) was issued in May 2014.
	RAPP 7&8, Rawatbhata	Chittorgarh, Rajasthan	NPCIL	700 MWe PHWRs each, of indigenous design	• Clearance for Major Equipment Erection (last stage of construction consent) was issued in May 2014
	PFBR, Kalpakkam	Kancheepuram/, Tamilnadu	Bhartiya Vidyut Nigam (BHAVINI)	500 MWe Prototype Fast Breeder Reactor each, of indigenous design	• Preparatory activities for commissioning in progress
Commissioning	KKNPP-1&2, Kudankulam	Tirunelveli, Tamilnadu	NPCIL	1000 MWe VVER (light water reactor) each, of Russian Design	• License for operation of KKNPP-1 was given in July 2015. License valid till June 2020 • KKNPP-2 under commissioning.

Table 2.2: Status of various under construction fuel cycle facilities being reviewed by AERB

Stage	Project	Dist., State/ UT	Utility/Licensee/ Applicant	Project Details	Remarks
Construction	**Demonstration Fast Reactor Fuel Reprocessing Plant (DFRP), Kalpakkam**	Kancheepuram /Tamil Nadu	IGCAR	Reprocessing facility for spent fuel from Fast Breeder Test Reactor (FBTR).	• Construction consent was issued in 2006 • Construction activities is in progress
Construction	**Fast Reactor Fuel Reprocessing Facility (FRFCF), Kalpakkam**	Kancheepuram /Tamil Nadu	IGCAR	Integrated facility for recycling spent fuel from PFBR. The project includes fuel fabrication & assembly, reprocessing and waste management facilities.	• Construction consent was issued in 2013. Site excavation in progress, a part of construction stage
Construction	**Demonstration Facility for Metallic Fuel Fabrication (DFMF), Kalpakkam**	Kancheepuram / Tamil Nadu	IGCAR	A small scale technology demonstration facility for Metallic fuel Fabrication.	• Application for Construction sConsent is under review
Construction	**PHWR Fuel Fabrication Facility and Zircaloy Fabrication Facility, Rawatbhata,**	Chittorgarh, Rajasthan	Nuclear Fuel Complex, Kota	Fabrication facility for PHWR fuel and Zircaloy components.	• Siting consent was issued in 2014. • Application for construction consent is under review

the backup passive coolant injection system, had shown some variabilities in its performance during commissioning tests. While the DCV was performing its safety function satisfactorily, it has shown variabilities in its functioning while normalizing the coolant system requiring operator attention. To address the issue, extensive laboratory tests of the DCVs were undertaken with modified internals as part of refinement. The refined DCVs were further in-situ tested in KKNPP Unit-1 and their performance was found satisfactory. The refined DCVs are also to be installed in KKNPP Unit-2. As a long term solution, an alternate design of the DCV is being pursued, which is currently undergoing qualification test.

AERB received the Applications for Initial Fuel Loading (IFL) and First Approach to Criticality (FAC) on February 16, 2016 and March 8, 2016 respectively. These were under review in AERB, as on March 31, 2016.

(After satisfactory resolution of various issues related to these, AERB issued clearances for IFL and FAC on May 24, 2016 and June 27,2016 respectively. The unit achieved criticality on July 10, 2016).

(iii) Kudankulam Nuclear Power Project -3&4 (KKNPP-3&4)

Top head of Reactor Pressure Vessel at KKNPP Unit-2

Inspection of Reactor Pressure Vessel of KKNPP Unit-2 in progress

AERB issued the Siting consent for four more VVER units of 1000 MWe (KKNPP – 3 to 6) in 2011. During the year, AERB issued clearance for Site Excavation (i.e. first stage of construction consent) for KKNPP Unit- 3 &4, on January 21, 2016.

The design of KKNPP-3&4 is similar to the design of KKNPP-1&2. In this regard, safety review of Preliminary Safety Analysis Report (PSAR) pertaining to clearance for excavation consent of KKNPP-3&4 was carried out. The reviews covered site characteristics aspects, derivation of design basis parameters for external events, classification of Structures, Systems and Components (SSCs), general design criteria, layout of NPP and design basis for civil engineering structures. The reviews also covered estimation of storm surge values for Design Basis Flood Level (DBFL) at Kudankulam site and it was noted that sufficient margins beyond the DBFL are available vis-à-vis plant grade elevation.

The reviews related to security aspects of KKNPP-3 & 4 were completed by the concerned committee of AERB, including those applicable during construction. The safety reviews being carried out by AERB for this NPP is based on the requirements of latest AERB Safety Code on 'Site Evaluation of Nuclear Facilities' (AERB/NF/SC/S-2014) and AERB safety code on 'Light Water Reactors based NPPs' (AERB/NPP-LWR/SC/D-2015). This code incorporates requirements of latest IAEA standards, as well as the relevant lessons learned from the Fukushima accident.

Excavation for KKNPP Unit-4 Reactor Building and Turbine Building under progress

(iv) Jaitapur Nuclear Power Project (JNPP)

Six units of Evolutionary Pressurised Reactor (EPR) each of 1650 MWe capacity, are proposed to be setup at Jaitapur, Maharashtra. NPCIL application and relevant submissions for Siting Consent for JNPP- 1 to 6 were reviewed by the Site Evaluation Committee of AERB. Further, submissions necessary to complete the site evaluation review by AERB were identified and communicated to NPCIL.

Pre-project activities are in progress. NPCIL has submitted Application to Ministry of Environment and Forests (MoEF) for extension of Validity of Environmental Clearance of JNPP 1 to 6. Permanent Meteorological Station has been commissioned for collecting site specific data.

A.2. FAST BREEDER REACTOR BASED NPPs

(i) Prototype Fast Breeder Reactor (PFBR)

The construction activities of PFBR have been completed and are under pre-commissioning stage. As part of pre-commissioning, AERB permitted melting of sodium in one of the Secondary Sodium Storage Tank and its recirculation for purification. Subsequently, this activity was carried out at PFBR.

During the year, preparatory activities for conducting the Integrated Leak Rate Test (ILRT) of reactor containment building were taken up. Also preparatory activities related to commissioning of fuel handling systems, control rod drive mechanisms, conduct of in-service inspections and training of plant operators on the full scope simulator were in progress.

Pre-Commissioning Activities in progress at PFBR Site,

(ii) Fast Breeder Reactor (FBR) -1&2

Twin Units of FBR-1&2 are planned to be set at Kalpakkam, near the existing PFBR plant. Presently, pre-project activities are in progress. Application seeking Siting Consent for FBR-1&2 and relevant submissions are under review by Site Evaluation Committee (SEC-FBR-1&2).

A.3. PRESSURIZED HEAVY WATER REACTOR (PHWR) BASED NPPs

Currently two twin-unit 700 MWe PHWR NPPs are undergoing construction at Kakrapar Atomic Power Project (KAPP-3&4), Gujarat and at the Rajasthan Atomic Power Project (RAPP-7&8) site at Rawatbhata. AERB is currently reviewing the application for construction consent for Gorakhpur Haryana Anu Vidyut Pariyojana-1, 2 (GHAVP-1&2), Haryana.

i. KAPP-3&4 and RAPP 7&8

Currently two twin-unit 700 MWe PHWR NPPs are undergoing construction at Kakrapar Atomic Power Project (KAPP-3&4), Gujarat and at the Rajasthan Atomic Power Project (RAPP-7&8) site at Rawatbhata. AERB had issued Clearances for Erection of Major Equipment (last sub stage of construction consent) for KAPP-3&4 and RAPP-7&8 on May 26, 2014 and March 05, 2015 respectively. Civil construction activities related to safety and non-safety buildings are in progress at both the Sites.

Erection activity in progress at the reactor building of RAPP- 7 &8

Preparatory work on core components in progress at RAPP- 7 &8

AERB continued the review of civil engineering aspects related to design and construction of safety related structures of KAPP – 3&4. The aspects related to changes in the location of construction joints and construction of ring beam of IC wall were reviewed. Mock-up scheme and results were reviewed and accepted by AERB. AERB committee for reviewing security aspects has completed the review of relevant security aspects.

Electrical Installation work in progress at KAPP-3&4

ii. GHAVP-1&2

Four Units of indigenously designed 700 MWe PHWRs are planned to be set up at Gorakhpur, Haryana (GHAVP-1 to 4). The site for GHAVP 1-4 is located in alluvial planes of Indo-Gangetic Basin, at about 40 km from Hisar, Haryana. Design of these units is similar to KAPP-3&4 and RAPP-7&8, except for some site specific changes. The Site Evaluation Report of GHAVP submitted by NPCIL and relevant submissions for siting consent were reviewed by AERB. Safety review for siting consent covered compliance to the requirements stipulated in recently issued revised AERB Safety Code on 'Site Evaluation of Nuclear Facilities'(AERB/NF/SC/ S-2014) and guidelines given in AERB Safety Guides on Siting of NPPs, other relevant International Standards as well as stipulations made during site selection. Detailed geophysical and metrological investigations were required to be carried out to ascertain the suitability of the site in respect of AERB requirements.

The site was found to be beyond the screening distance values corresponding to all rejection criteria, as stipulated in the revised AERB Siting Code and was found to be engineerable with respect to natural hazards and human induced phenomena. Estimated radiological impacts during normal and accident conditions are within the limits stipulated by AERB.

Based on the satisfactory outcome of review and assessment, AERB issued Siting consent for constructing four 700 MWe PHWRs at Gorakhpur, Haryana on July 08, 2015. Subsequently, NPCIL has submitted application seeking Clearance for Excavation for GHAVP-1&2 to AERB, which is currently under review.

Highlights of the safety review of PHWRs under construction are given below,

- **Pressure Tube (PT) Rolling**

A detailed review of the Quality Assurance Program of Pressure Tubes (PT) installation at KAPP-3 was carried out by AERB. NPCIL was asked to ensure thorough checks and strict QA during the rolling operations. Compliance of the same is being verified periodically during regulatory inspections. Further, a detailed review of QA practices in this regard were also initiated following pressure tube leak in KAPS Unit-2 (*Refer section 2.2.3 (v) for details on KAPS Unit 2 incident*).

- **Experimental Validation of Containment Spray System**

In 700 MWe PHWRs, certain new features are envisaged in design. The Containment Spray System is one such feature intended for pressure suppression within the containment in the post-accident scenario. Towards demonstration of efficacy of this new system, experiments for validation of certain aspects such as iodine removal and depressurization of containment were conducted at IIT Bombay. Experts from AERB witnessed some of these experiments.

- **Passive Decay Heat Removal System(PDHRS)**

Passive Decay Heat Removal System has been introduced in 700MWe PHWR as a First- of - A - Kind (FOAK) system to remove the core decay heat through Steam Generators under Station Black Out (SBO) condition. The efficacy of PDHRS system was demonstrated by experiments conducted at IIT Bombay. To further qualify certain aspects of the system, experiments are being planned at NPCIL Thermal-hydraulic Test Facility (NTTF) at Tarapur incorporating various issues that emanated during review by AERB.

- **Post Fukushima Safety Enhancements**

As part of Post-Fukushima safety enhancement, various safety measures such as, automatic reactor trip on seismic event, fire-water hook-ups to reactor systems, air- cooled Diesel Generator, Hydrogen management features, and Severe Accident Parameter Monitoring System, full length Calandria Vault level measurement, etc. are being incorporated. Based on the regulatory review of Generic Severe Accident Management Guidelines (SAMGs), plant specific SAMGs are being developed by NPCIL.

A.4 INDIAN PRESSURIZED WATER REACTOR (IPWR)

BARC jointly with NPCIL is working for finalizing the design of Indian Pressurised Water Reactor (IPWR). IPWR is an indigenous PWR design with a power rating of 2700 MWt – 900 MWe, incorporating advanced safety features, including passive safety systems similar to the ones developed for the Advanced Heavy Water Reactor (AHWR). The IPWR also incorporates layout features of the 700 MWe PHWRs being constructed in India. During 2015-16, AERB undertook a pre-consenting review of the design of IPWR based on the request from BARC.

(B) FUEL CYCLE FACILITIES UNDER CONSTRUCTION: REVIEW STATUS

Safety review activities related to the fuel cycle facilities (refer Table 2.2.) continued during the year.

B.1 DEMONSTRATION FAST REACTOR FUEL REPROCESSING PLANT (DFRP)

This plant is being set up at Kalpakkam for reprocessing of the spent fuel from Fast Breeder Test Reactor (FBTR) on regular basis and PFBR fuel on experimental basis. Construction of Process Plant Facility (PPF) is nearing completion. In Reconversion Lab area, Fume hood and Fume hood exhaust duct fabrication, supply and exhaust piping of reconversion boxes is under progress. Based on the recommendation of AERB, Seismic requalification of DFRP was done. Site was also asked to perform necessary radiometry test on cell walls as a part of confirmatory test for shielding and submit the test results to AERB for further review.

B.2 FAST REACTOR FUEL REPROCESSING FACILITY (FRFCF)

Fast Reactor Fuel Reprocessing Facility (FRFCF) is an integrated facility being set up at Kalpakkam. The facility will be used for recycling the spent fuel from PFBR, including fuel fabrication & assembly, reprocessing and waste management. Consent for construction of this facility was issued by AERB in the year 2013. Presently, site excavation work is in progress, a part of construction stage.

The construction of administrative, training center, canteen, central surveillance, safety & health physics buildings are in progress.

B.3 DEMONSTRATION FACILITY FOR METALLIC FUEL FABRICATION (DFMF)

A small scale Demonstration Facility for Metallic Fuel Fabrication (DFMF) is proposed for technology demonstration of fabrication of metallic fuel pins. The application submitted for Construction Consent along with supporting documents is under review.

B.4 TUMALLAPALLE ORE PROCESSING FACILITY

The proposals pertaining to raising of tailings dam height and authorization for disposal/transfer of radioactive wastes from Tummalapalle mill of UCIL is under review by AERB.

2.3.1 Regulatory Inspection

AERB carries out Regulatory Inspections (RI) of the Nuclear Facilities to check compliance to regulatory requirements and consenting conditions. The report of the RI with observations and recommended actions is prepared and forwarded to the facility for taking corrective actions. The observations/ recommendations made during the Regulatory Inspections are broadly categorized adopting the graded approach for follow up of their review and resolution. The facility is required to submit an action taken report on the deficiencies brought out during the inspection within the specified time frame. These submissions are reviewed in AERB for disposition and need for enforcement actions, if any. AERB may also initiate enforcement actions, if in its opinion the licensee has violated the conditions of the license willfully or otherwise or misinformed or did not divulge the information having bearing on safety after specifying the reasons for such actions. The regulatory inspection team also has the powers to take on-the-spot enforcement actions, if necessary, in cases of serious non-compliances. The enforcement actions may include one or more of the following:

a. A written directive for satisfactory rectification of the deficiency or deviation detected during inspection;
b. Written directive to applicant/licensee for improvement within a reasonable time frame;
c. Orders to curtail or stop activity;
d. Modification, suspension or revocation of license; and
e. Initiate legal proceedings under provisions of the Atomic Energy Act.

The regulatory inspections are carried out as per the guidelines given in AERB safety guide on 'Regulatory Inspection and Enforcement in Nuclear and Radiation Facilities (AERB/SG/G-4)'. The provisions of the guide as applicable to different types of facilities are further elaborated in the respective safety manuals on Regulatory Inspections, (AERB/NPP/SM/G-1, AERB/NF / SM /G-2 & AERB / RF / SM / G-3).

Inspections are carried out periodically as well as under special circumstances. Generally, the inspections are carried out with prior announcement. AERB also carries out special unannounced/surprise inspections with specific objectives as deemed necessary.

During construction and commissioning stages of nuclear power projects, the planned inspections are carried out at a frequency of four inspections in a year. Generally, an inspection team consisting of typically eight members carries out inspection of the facility, spanning over a period of about one week. Composition of the team and areas to be inspected are pre-decided, taking into consideration the status of the facility and the safety issues under consideration. In addition to normal regulatory inspections, AERB also identifies a list of important activities during construction and commissioning as hold points for which the facility is required to inform AERB in advance for deputing its representatives/experts in the respective areas to witness the relevant activities. In the case of KK NPP-1&2 which was the first Pressurized Water Reactor (PWR) based NPP in India, AERB observers were deputed to provide regulatory surveillance during the commissioning activities of KK NPP-1&2 on a continuous basis, in addition to routine regulatory inspections and deputation of the experts for witnessing important activities.

The information on the regulatory inspection carried out by AERB in the nuclear facilities under construction during the year 2015-16 is presented in Table 2.4.

Table- 2.4: Regulatory Inspections by AERB during the year 2015-16 in the Nuclear Facilities under construction

Project	No. of RI
KKNPP-1&2	4
KKNPP-3&4	2
KAPP-3&4	8
RAPP-7&8	8
PFBR	5
DFRP	2
FRFCF	2
Total	**31**

During these inspections, a large no.s. of observations are made by the inspection team of AERB. These observations/recommendations are further categorized adopting the graded approach as an internal mechanism for follow up of their review and resolution. The implementation of Quality Assurance requirements to assure that safety principles are given highest priority, is adequately addressed during these inspections.

Typical nature of these observations / recommendations which emanated from these RIs in the projects under construction is given below:

- In Control building of PFBR, BHAVINI, a passage was observed very close to the RCB wall. In view possibility for this passage to become active in case radioactivity builds up inside RCB, Site was asked to provide radiation monitors and access control in this area.

- At PFBR, BHAVINI, it was observed that the skirt portion of a Secondary Sodium Storage Tank (which supports the tank), was not insulated. It was noted that, the temperature of the skirt portion will be very high when the sodium storage tank is heated. In view of above, AERB inspection team recommended PFBR to insulate the skirt portion of the mentioned sodium storage tank to avoid burn injuries and failure /malfunctioning of some nearby instruments, after carrying out required assessment.

- As per approved design of KAPP – 3 & 4, Containment Spray System (CSS) pumps discharge piping has one manual isolation valve in series with two parallel Motorised Valves before it enters into the Containment. However, it was noted from the revised drawing that one more manual isolation valve is included in this pipeline towards Containment side. NPCIL was asked to submit changes made in safety related system to AERB for review before implementation.

- At KAPP – 3 & 4, it was observed from the QA records for feeder fabrication indicated that 20% coverage was given by Site QA for activities like feeder bending, Dye Penetration Test (DPT) of bent surface and root and final pass DPT of weld joints. NPCIL was asked to provide 100 % QA coverage for important Civil structures, all equipment in Calandria Vault and Class-I components. Similar recommendation was also made for RAPP-7&8. Both sites are revising the QA plans to address the same.

- At RAPP – 7, some unfinished machining marks were observed outside annular region near base plate of End shield (North) of RAPP-7 which was to be subsequently installed inside the grouted concrete portion. Site was asked to obtain designer's concurrence before grouting the bottom portion of End Shield. Subsequently, Site has carried out Dye Penetration Test of the area and found the results satisfactory and obtained designer's concurrence for the same.

- At Reactor Building of RAPP 7& 8, a Fire Fighting Water (FFW) pipeline was routed through a rectangular opening touching one side of the opening. FFW being a system requiring seismic qualification, RAPP 7 & 8 was asked to maintain the required gap as per design. Subsequently, RAPP 7 & 8 took corrective action for the same.

2.4 OPERATING NUCLEAR POWER PLANTS AND RESEARCH REACTORS

2.4.1 Operational Safety Review:

Currently there are twenty one nuclear power plants in operation, including KKNPP Unit 1 which was issued license for operation in July 2015. The list of operating nuclear power plants is presented in Table 2.5.

AERB continued its regulatory supervision of these plants. During the year 2015-16, applications for issuance/renewal of licenses submitted by MAPS, RAPS 5 & 6, TAPS -1 & 2, FBTR, KAMINI- IGCAR were reviewed by AERB.

2.4.2 Consents / Clearances / Permissions Issued

During the year, a number of applications from the utilities were reviewed and licenses for operations / clearances / permissions were issued. Important among these are:

- Renewal of license for operation of MAPS up to June 30, 2016
- Renewal of license for operation of RAPS-5&6 up to December 2017.
- Renewal of license for operation of TAPS-1&2 up to March 31, 2017
- Issuance of License for operation of KAMINI, IGCAR up to June 30, 2016
- Permission of 24th irradiation campaign of FBTR, IGCAR

2.4.3. Safety Review of Operating Nuclear Facilities

Number of meetings conducted by various safety committees / standing committees during the year 2015-16 is given in Table 2.6.

Table 2.6: Meetings of Safety Committees

Name of the Safety Committe	No. of meetings
SARCOP	19
TAPS-1&2 Safety Committee	9
TAPS-3&4 Safety Committee	10
RAPS-MAPS Safety Committee (RMSC)	10
NAPS-KAPS Safety Committee (NKSC)	14
KGS-1&2 and RAPS-3&4 Safety Committee (KRSC-1)	10
KGS-3&4 and RAPS-5&6 Safety Committee (KRSC-2)	08
KK Safety Committee (KKSC)	07
IGCAR Safety Committee	06
SARCOP Standing Committee on Reactor Physics (SC-RP)	08
SARCOP Standing Committee on Control, Instrumentation & Computer based systems (SCCI&CS)	03
Expert Group on Coolant Channels (EGCC)	05
Civil Engineering Safety Committee for Operating Plants (CESCOP)	04
Expert Group on Equipment Qualification (EG-EQ)	06

Table 2.5: List of Operating Nuclear Power Plants

NPP	Unit	Site/ District/State	Type	Gross Capacity (MWe)	Commencement of Operation	Validity of Current License
Kaiga Generating Station (KGS)- 1 & 2	KGS-1	Kaiga/North Uttar Kannada Dist./ Karnataka	PHWR	220	November-2000	May 2017
	KGS-2		PHWR	220	March-2000	
Kaiga Generating Station (KGS) 3 & 4	KGS-3		PHWR	220	May-2007	April 2018
	KGS-4		PHWR	220	January-2011	
Kakrapar Atomic Power Station (KAPS) 1 & 2	KAPS-1	Kakrapar/Tapi Dist./Gujarat	PHWR	220	May-1993	July 2019
	KAPS-2		PHWR	220	September-1995	
Madras Atomic Power Station (MAPS) 1 & 2	MAPS-1	Kalpakkam/Kancheepuram Dist./Tamil Nadu	PHWR	220	January-1984	December 2020 *(as on June 2016)*
	MAPS-2		PHWR	220	March-1986	
Narora Atomic **Power Station (NAPS) 1&2**	NAPS-1	Narora/Bulandshahar Dist./Uttar Pradesh	PHWR	220	January-1991	June 2018
	NAPS-2		PHWR	220	July-1992	
Rajasthan Atomic Power Station (RAPS) 1&2	RAPS-1#	Rawatbhata /Chithaurgargh Dist./Rajasthan	PHWR	100	December-1973	December 2016
	RAPS-2		PHWR	200	April-1981	
Rajasthan Atomic Power Station (RAPS) 3&4	RAPS-3		PHWR	220	June-2000	October 2017
	RAPS-4		PHWR	220	December-2000	

NPP	Unit	Site/ District/State	Type	Gross Capacity (MWe)	Commencement of Operation	Validity of Current License
Rajasthan Atomic Power Station (RAPS) 5&6	RAPS-5		PHWR	220	February-2010	December 2017
	RAPS-6		PHWR	220	March-2010	
Tarapur Atomic Power Station (TAPS) 1&2	TAPS-1	Tarapur/Palghar Dist./ Maharashtra	BWR	160	October-1969	March 2017
	TAPS-2		BWR	160	October-1969	
Tarapur Atomic Power Station (TAPS) 3&4	TAPS-3		PHWR	540	August -2006	August 2021
	TAPS-4		PHWR	540	September -2005	
Kudankulam Nuclear Power Plant (KKNPP) 1	KKNPP-1	Kudankulam/Thirunelveli Dist./ Tamil Nadu	PWR	1000	December-2014	July 2020

 # Unit under shutdown since 2004 and the reactor core is defueled.

i. Periodic Safety Review of TAPS - 1 & 2

TAPS Units – 1 & 2 underwent Periodic Safety Review (PSR) as a pre-requisite for renewal of its operating license beyond March, 2016. Based on the outcome of the PSR, the License for operation of the units was extended for a period of one year i.e. up to March 31, 2017.

TAPS-1&2 had a satisfactory safety performance. The radioactive discharges from the plant remained within the AERB authorized limits. There was no case of personal exposure beyond AERB authorized limits. The dose to the member of public around Tarapur site was small fraction of AERB authorized limit. The results of environmental samples have not shown any significant impact on the environment.

The In-service inspections carried out so far have not revealed any significant degradation in the structures, systems and components (SSCs) of the plant. The reactor pressure vessels (RPV) of TAPS 1 & 2 were not having any provisions for in-service inspection, as originally designed. As part of the reviews carried out for continued long term operation (carried out during 2000- 2005), AERB had stipulated for developing inspection methodologies/equipment for health assessment of the RPVs. Accordingly, inspections were carried out during the recent refueling outages of both TAPS 1 & 2 using specially developed inspection equipment. For the first time the core belt line region welds were also included in the inspection of TAPS-2 RPV. Special inspection tools were fabricated and reviewed for their design and reactor worthiness; for gathering and recording the inspection findings a data acquisition system. Software for data analysis were designed indigenously and validated. The inspection findings were independently evaluated by three different agencies viz. NPCIL, BARC and IGCAR. The structural integrity analysis was conducted by three different agencies viz. NPCIL, BARC and AERB. The results of the tests conducted on the RPV material surveillance coupon removed from the TAPS1 RPV were also used for the evaluation for the fitness of service of the TAPS2 RPV. The structural integrity assessments of RPVs carried out based on the inspection results have confirmed availability of sufficient safety margins for continued service of RPVs.

The past inspections carried out on the civil structures of the plants as part of ageing management did not reveal any significant degradation.

TAPS has implemented most of the important safety upgrades identified post Fukushima NPP accident including, hook up provisions for injection of water to important systems, automatic seismic trip, flood proofing of the emergency diesel generators by raising the foundation of these equipment, seismic re-evaluation and strengthening of identified systems and augmenting the provisions for monitoring of key plant parameters during severe accident situations. The actions for implementation of the long term safety upgrades such as installation of primary containment inerting system, Containment Filtered Venting Systems (CFVSs), Decision Support System (DSS) for off-site emergency management, augmentation of on-site water storage and establishing On-Site Emergency Support Centre (OESC) are in progress.

ii. Inspection of RPVs of TAPS 1 & 2

TAPS Unit 1 & 2 underwent inspection of the RPV welds and structural integrity assessments during the 23rd refueling outage of Unit 1 (October 12, 2014 to September 4, 2015) and the outage of Unit 2 since September 10, 2015.

iii. Renewal of license for operation of RAPS-5&6

The license for operation of RAPS-5&6 was valid up to May 31, 2015.As per the regulatory requirement, RAPS – 5 & 6 submitted the Application for Renewal of License (ARL) which was reviewed in AERB. Based on the assessment of the application, the license for operation of RAPS-5&6 was extended up to December 2017.

The assessment showed that the safety performance of the RAPS-5&6 for last five years (2010 to 2015) had been satisfactory. The collective dose of the plant remained within the approved dose budget. There was no case of individual exposure exceeding the AERB prescribed limit. The radioactive releases from the station remained well within the technical specifications limits. In-service inspection and surveillance have shown that the condition of various system / equipment is satisfactory. Station had instituted a comprehensive Equipment Qualification (EQ) programme for qualifying the components required to function during accident conditions. Based on the results of EQ test, some components had been replaced and actions were in progress for replacement of the other identified components. Revision of documents such Radiation Protection Procedure (RPP) manual, Emergency Preparedness and Response (EPR) manual, Final Safety

Analysis Report (FSAR) was in progress. Station had implemented a number of post Fukushima identified upgrades such as hook up provision for water addition into important reactor systems, provision of automatic reactor trip on seismic events, provision for monitoring of critical plant parameters etc. However, actions were in progress for implementation of other long term post Fukushima recommendations related to provision of Passive Decay Heat Removal System (PDHRS), Containment filtered venting, creation of Onsite emergency support facility, preparation of station specific accident management guidelines etc.

iv. Periodic Safety Review (PSR) of MAPS-1&2

MAPS Units – 1 & 2 underwent Periodic Safety Review (PSR) as a pre-requisite for renewal of its operating license beyond December 2015. Based on the outcome of the PSR, the License for operation of the units was extended for a limited period up to June 30, 2016.

MAPS-1&2 had a satisfactory safety performance. The radioactive discharges from the plant were within the AERB authorized limits. There was no case of personal exposure beyond AERB authorized limits. Dose to the member of public due to operation of MAPS was a small fraction of AERB authorized limit.

The results of in-service inspections and surveillance activities indicated that the condition of various systems / equipment is satisfactory. Station has updated mandatory documents such as EPR manuals, RPP manual, FSAR etc. Station has made good progress towards meeting the requirement of equipment qualification. MAPS has implemented some of the important safety upgrades identified post Fukushima NPP accident such as hook up provisions for injection of water to important systems, automatic reactor trip on seismic event, procurement of additional fire tender, provision for monitoring the important plant parameters during severe accident, augmentation of on-site water storage etc. However, actions were in progress for implementing long term upgrades such as installation of Passive Decay Heat Removal System (PDHRS), Containment Filtered Venting System (CFVS), Decision Support System (DSS) etc. It was found that certain issues pertaining to health assessment of civil structures and inaccessible components as well as certain recommendations relating to severe accident analysis were still to be satisfactorily addressed.

v. Incidents of Pressure Tube Leaks in KAPS Unit-2 & Unit-1

On July 1, 2015, KAPS Unit-2 experienced an event of small leak from a pressure tube of primary coolant system while operating at power level of 203 MWe. The leak was indicated by Annulus Gas Monitoring System (AGMS). After the indication of leak, the reactor was manually shutdown and brought to cold & depressurized state. Immediately after receipt of the event notification, AERB instructed the plant authorities that KAPS Unit-2 restart would be subject to regulatory review and clearance. During July 2-4, 2015, a special regulatory inspection of KAPS Unit-2 was carried out by the AERB to gather the first-hand information and independent assessment of the event. The plant safety status and investigation activities after the event were monitored by AERB through daily status reports.

The in-situ inspection of the leaked pressure tube revealed a small tight longitudinal crack near the cold end rolled joint which was later confirmed during the hot cell examinations. Since the crack was near the rolled joint, the failure mechanism was suspected to be similar to the failures earlier experienced in CANDU reactors. Considering this and KAPS Unit-2 life of 15.3 Full Power Years (FPYs)/18 Hot Operating Years (HOYs) before the event, a thorough review of the coolant channels life management program was undertaken and many coolant channels of the reactor were inspected after a careful selection. No abnormality was observed in these inspections. The examinations in the hot cell revealed an unprecedented observation of localised corrosion spots on the exterior surface of the leaked pressure tube. It was suspected that the localized corrosion of pressure tube exterior surface might have occurred due to its prolonged exposure to steam environment following leak from pressure tube. In view of this concern, another channel from the same zone of the reactor was removed for examination. Similar corrosion spots were also noticed on the pressure tube exterior surface of this channel. Subsequently, AERB emphasized for a non-destructive technique for detection of localized corrosion spots on the pressure tube exterior surface. Following this, a developmental work was undertaken by the utility to tune the existing coolant channel inspection tool for detection of localized corrosion spots on the pressure tube exterior surface.

While the investigations of KAPS Unit-2 event were in progress, KAPS Unit-1 experienced an event of pressure tube failure on March 11, 2016. Following the event, reactor underwent automatic shutdown and all safety systems provided in the design to deal with the pressure tube failure event functioned as intended. The plant emergency was declared immediately after the event. After receiving the information about the event, AERB activated its Nuclear& Radiological Emergency Monitoring Cell (NREMC) to closely monitor the event progression and to assess the safety status of the plant. An observer team was deputed at KAPS site during March 12-13, 2016 for initial on the spot assessment of the event. The event related developments and radiological status of the plant were communicated to public and media through regular press releases.

The post event investigation activities identified Q-15 as the failed channel. This channel was successfully defueled and isolated from primary coolant system after a thorough review and approval by AERB. With this, the leak from primary coolant system stopped and the plant emergency was terminated on March 21, 2016.

The event was categorized as 'Small LOCA' and provisionally rated at 'Level 1' on INES. There was no fuel failure because of the event. The event did not result in any radiation overexposure to plant personnel. The radioactivity releases remained within the specified limits for normal operation. During the course of plant emergency, environmental survey within the site as well as in the off-site domain up to 30 km from the plant was carried out. This confirmed that there was no increase in the background radiation levels.

Presently, both the KAPS Units are under shut down and the investigations are in progress to determine the root causes of the events.

vi. Periodic Safety Review of KAMINI, IGCAR

Similar to the regulatory system followed for regulation of nuclear power plants, AERB had instituted the requirement of conduct of periodic safety reviews for renewal of operating License of research reactor under its purview. During this year, AERB reviewed the PSR of a research reactor KAMINI (Kalpakkam MINI). KAMINI is a U-233 fuelled, light water moderated/cooled and beryllium oxide (BeO) reflected low power research reactor. KAMINI attained its first criticality on October 29, 1996. Initial authorization for regular operation of KAMINI was granted on June 29, 1998. On a recommendation of AERB, IGCAR carried out Periodic Safety Review (PSR) of the KAMINI, in-line with the guidelines given in AERB/SG/G-1 and submitted application to AERB for issuance of a formal license for operation of the facility. Based on the review, it was noted that, the performance of KAMINI had been satisfactory during the reporting period. Several modifications / replacements had been carried out in order to improve performance & reliability of the systems and enhancement of safety after taking approval from AERB. While the regulatory review of PSR is continuing, AERB extended the license for operation to KAMINI for a limited period i.e. up to June 30, 2016, based on preliminary review.

vii. Permission for 24th Irradiation Campaign of FBTR

During 2014-15, AERB had granted permission for 23rd irradiation campaign of FBTR for continuation of irradiation of the sodium bonded metallic fuel pins at two locations. This includes long term irradiation of structural materials and irradiation of natural uranium Zr sodium – bonded metallic fuel pins. The 23rd irradiation campaign was started on October 11, 2014 and completed on May 23, 2015. Subsequently, IGCAR submitted an application seeking permission for 24th irradiation campaign of FBTR to continue the irradiation experiments. After satisfactory safety review of the application, AERB permitted the commencement of 24th irradiation campaign of FBTR.

viii. Implementation of Safety enhancements in NPPs following the accidents at Fukushima NPP, Japan.

The safety reviews carried out for Indian NPPs following the accident at Fukushima NPP, have shown that Indian NPPs have inherent strengths in dealing with external hazards. However, based on the review, certain safety enhancements were identified for further strengthening the defenses against external hazards of extreme magnitude exceeding the plant design bases and to strengthen the severe accident management capabilities. These actions were classified as short term, medium term and long term activities for their implementation. AERB has been closely monitoring the progress of implementation of these safety enhancements. As of now, implementations of the short term and medium term enhancements have been mostly completed in all the NPPs. The long term activities mostly involve those which need significant development/ manufacturing/ procurement efforts involving long lead times.

The current status of implementation of long term measures is as below:

a) *Enhancing severe accident management programme*

Preventive measures that are required to be taken under severe accident condition such as hook up provisions to important system have been implemented. The Generic Technical Basis Document (TBD) on 'Accident Management Guidelines (AMGs)' for Indian PHWRs has been reviewed and accepted by AERB. Based on this generic document, station specific accident management guidelines have been prepared for all sites. Surveillance program have been established for monitoring the healthiness of all the provisions required for implementing these guidelines. The enhanced AMGs for TAPS-1&2 (BWR units) is presently being reviewed in AERB.

b) *Strengthening hydrogen management provisions*

The proposed hydrogen management scheme in Indian PHWRs includes provision of suitable number of Passive Catalytic Recombiner Device (PCRD) along with provisions for homogenizing the containment atmosphere. PCRDs have been indigenously developed and performance checks and qualification were carried out at the Hydrogen Recombiner Test Facility at Tarapur. The technology transfer for large scale manufacturing of PCRDs has been carried out. NPCIL has proposed to install the PCRDs at all NPPs in a phased manner.

PCRD Test Vessel at NPCIL R &D Center, Tarapur

CFVS test facility at TAPS-1&2 and arrival of scrubber tank

c) *Provision of containment filtered venting*

Containment Filtered Venting Systems (CFVS) for Indian NPPs are planned to be installed to prevent containment pressure exceeding the design pressure. This system is based on wet scrubbing concept and has been developed indigenously through extensive experimentation. The system design is currently being reviewed by AERB. Construction activities of CFVS for TAPS-1&2 are in progress.

d) *On-site emergency support centre*

AERB has framed requirements and guidelines for establishing On-Site Emergency Support Centers (OESCs) at all NPPs. This facility will have capability to remain functional under radiological conditions following a severe accident and should be capable of withstanding extreme external events (flood, cyclone, earthquake, etc.). This facility will be in addition to the existing emergency control centers at the plants. The design basis for the facility has been finalised and the work for construction of the facility at sites is in progress.

Photographs of some of the safety upgradation implemented at various NPPs is presented in subsequent page.

2.4.4 Regulatory Inspections

Regulatory inspections for operating NPPs are carried out twice a year. In general, the following areas are covered during a typical regulatory inspection of an operating NPP.

- Operation, Maintenance and Quality Assurance Programme.
- Adherence to the technical specifications for Operation
- Compliance to various regulatory recommendations.
- Adequacy of licensed staff at NPPs
- Performance of safety related systems.
- Radiation safety and ALARA practices.
- Emergency Preparedness
- Industrial Safety

Further, the physical protection systems of the NPP for security of systems affecting safety is carried out once in a year. Special inspections are conducted during Biennial shut downs (BSD) of the NPPs to assess the radiological safety aspects. Special regulatory inspections are also carried out as necessary following an event, depending on the safety significance or after major modifications in the plant and forms the basis for considering clearance for restart of the unit.

During the year, a total of fourty regulatory inspections of operating NPPs and research facilities were carried out, which included twenty scheduled inspections for nuclear & radiological safety aspects, eight scheduled inspections for nuclear security aspects, seven special inspections and three unannounced inspections (one each at KAPS-1&2, MAPS 1&2 and TAPS 1&2).Out of seven special regulatory inspections, six inspections were conducted during the biennial shutdown of NPP units at KAPS-1, KGS-4, RAPS-4, RAPS-6, MAPS-2 and KKNPP-1 to monitor the radiological safety aspects and one special regulatory inspection was conducted at TAPS-4 to check/review the compliance to Technical Specification requirements during BSD activities and performance of newly installed system during the BSD.

AERB follows-up the implementation of all the recommendations made during these inspections. The number of regulatory inspections of operating nuclear facilities during the period April 2015 to March 2016 is given in Table 2.7.

Table: 2.7: Number of regulatory inspections at the NPPs and research reactors (April 2015 to March 2016)

Unit	Number of Inspections	
	Planned	Special
TAPS-1&2	2	1
TAPS-3&4	2	1
RAPS-1&2	2	0
RAPS-3&4	2	1
RAPS-5&6	2	1
MAPS-1&2	2	2
NAPS-1&2	2	0
KAPS-1&2	1	2
KGS-1&2	2	0
KGS-3&4	2	1
KKNPP-1	1	1
FBTR & KAMINI	1	0
Total*	**21**	**10**

* In addition, scheduled inspections to cover aspects related to nuclear security and one unannounced inspection each was undertaken for KAPS-1&2, MAPS 1&2 and TAPS 1&2.

During these inspections, a large no.s. of observations are made by the inspection team of AERB. These observations/recommendations are further categorized adopting the graded approach as an internal mechanism for follow up of their review and resolution. Some of the typical important observations/recommendations having safety implications which emanated from these RIs in the operating NPPs and research reactors and the

Photographs of some of the safety upgradations implemented at various NPPs are shown below,

200 KVA mobile DG

200 KVA fixed DG

Hook ups at KGS- 1& 2

Seismic system annunciator to alert operator

Mockup for injection of water through hook up provision

Onsite Water Storage tank at MAPS

regulatory action taken are given below:

- At RAPS-1&2, failure of a few pneumatic valves were noted from records mainly due to poor quality of instrument air. The dust/moisture in the instrument air has choked the filters causing partial operation /failure of the valves to operate. Based on the recommendation of AERB, station has taken corrective actions by implementing procedure for monitoring the cleanliness of instrument air and also modified the maintenance procedure of the valves and to ensure cleanliness of the associated air filters during periodic maintenance jobs.

- During inspection of MAPS-1&2, it was observed that one radioactive source (Cs-137) was stored in the old Nuclear Training Centre (NTC) building for calibration purposes. This building was designated as Zone-1(plant area free from contamination), and thereby deviating from the zoning philosophy. In view this, the inspection team recommended that either the source should be shifted to Zone – 3 (plant area having potential to have radiological contamination) area storage room or suitable access control measures should be established at the location of this source. Subsequently, station established administrative controls like locking arrangement and monthly inventory checks to ensure security of source in the old NTC building. In addition, radiological shielding of the area was augmented and radiation monitors were installed at the exit of the room ensuring radiological safety of workers.

- PHWR based NPPs have up-gradation plant to improve the isotopic purity of heavy water. While exiting from the up-gradation plant, it is required to monitor personnel contamination to avoid spread of contamination. At NAPS, it was observed that, only one foot contamination monitor was kept at the exit of the upgrading plant. The inspection team recommended that hand contamination monitor should also be installed at the exit of upgrading plant. Based on the recommendation of AERB inspection team, NAPS installed a hand and foot monitor at the exit of the upgrading plant.

- The moderator system has an arrangement to collect heavy water leak from the seals of pumps and divert it to leakage collection tank, thus avoiding any external leak of heavy water from the seals. This water is then pumped back to the system after necessary checks of isotopic purity and other chemical parameters. At RAPS-2, it was observed that seal leak from one of the moderator system pumps was higher than normal. In view of certain situations of pump backup system failure may lead to loss of moderator inventory, AERB recommended to take necessary actions to arrest seal leaks, Subsequently, Station has replaced the affected pump seals.

- Fire water system is the back-up system for removal of heat from important systems & equipment of nuclear power plants. At MAPS, it was noted that that one of the diesel driven fire water pump had developed inadequate discharge pressure during routine surveillance testing. The investigations carried out by station indicated problem in the pump internal components. AERB inspectors recommended reviewing the preventive maintenance (PM) procedures and practices for similar pumps in light of the above incident to avoid such degradations at the incipient stage. Subsequently, station has carried out necessary changes in the preventive maintenance procedures so as to avoid repetition of such failures.

2.4.5 Licensing of Operating Staff

Operating personnel of NPPs are required to go through a licensing procedure which includes clearing checklists, written exams, walkthrough and finally Qualification interviews. The final assessment/ Qualification interviews for NPP operating personnel responsible for control room operation namely Shift Charge Engineer (SCE), Assistant Shift Charge Engineer (ASCE) and Control Engineer is conducted by the final assessment committee constituted by AERB, which includes AERB representatives. A candidate after successfully completing the pre-requisites of licensing procedure, including clearing checklists, written exams, walkthrough and scrutiny of training records, appears before this committee and only after satisfactory performance the candidate is licensed/re-licensed for the given position.

During the year, 24 meetings were held for licensing/re-licensing of operating personnel responsible for control room operations at various operating

NPPs and a total of 272 candidates were licensed / re-licensed.

In addition to this, three Control Room Assistants / Field Supervisors, one Junior Shift Engineer and one Shift In-charge were licensed / re-licensed for FBTR operation.

2.4.6 Significant Events

AERB requires NPPs to report 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 of events is done based on their safety significance and importance to operational safety experience feedback. Based on the established reporting criteria, event reports (ER) and significant event reports (SER) are submitted to AERB. The SERs received from the operating NPPs are rated on the International Nuclear and Radiological Event Scale (INES) of International Atomic Energy Agency (IAEA). The INES rates events at seven levels (1 to 7) depending on their safety significance as shown in Figure-2.1 below.

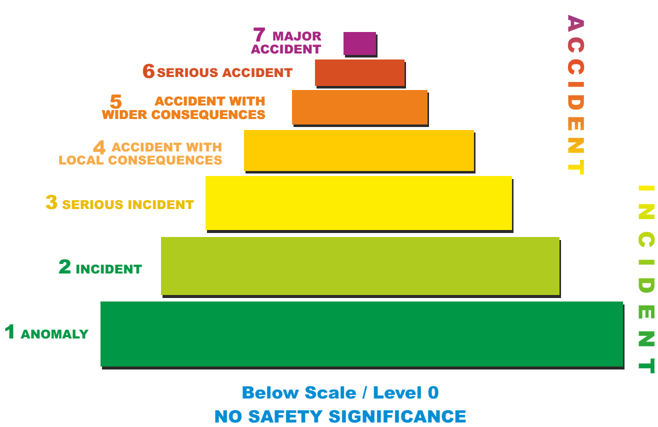


Figure-2.1: INES Event Scale

Events rated at level 4 and above are termed as 'Accidents'. The accidents at Chernobyl NPP in former USSR (now in Ukraine) in April 1986 and Fukushima NPPs in Japan in March 2011 were rated at level 7 on INES. 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 Below scale/level 0 means events that have no radiation safety significance.

In year 2015, a total of 42 significant events rated at level 0 on INES were reported from 21 operating NPPs. The number of SERs in each NPP and their ratings on INES are given in Table -2.8. These incidents were reviewed in detail by AERB addressing the root cause of the incidents and corrective actions to be taken to prevent recurrence of similar incidents at NPPs. The root cause analysis of the events of heavy water leaks from pressure tubes of KAPS-2 on July 1, 2015 and in KAPS-1 on March 11, 2016 are under review and the information on these is given in Section 2.2.3.(v).

For the purpose of analysis, the events were categorised as per the IAEA-IRS coding system. The classification of root causes of the significant events is given in Figure-2.2

Table-2.8: INES rating of Significant Events in NPPs during the Calendar year 2015

NPP	Number of Events of INES - 0	Number of Events of INES – 1 &above
TAPS -1&2	4	0
TAPS -3&4	6	0
RAPS -1&2	1	0
RAPS -3&4	9	0
RAPS -5&6	4	0
MAPS -1&2	3	0
NAPS -1&2	5	0
KAPS -1&2	2	0
KGS -1&2	6	0
KGS -3&4	0	0
KKNPP -1	2	0
Total	**42**	**0**

Event of upper absorber rods failure in KGS-2

At KGS-2, eight absorber rods are provided for flux flattening and to compensate for excess reactivity in the reactor. Four rods move into the core from the top, whereas remaining four rods move into the core from the bottom side of reactor core. Two incidents of upper absorber rods drop into the reactor core, one each on April 9, 2015 and July 24, 2015 were reported. The reactor power got reduced by 10% FP and 5% FP respectively. The reactor regulating system automatically compensated for the negative reactivity addition caused by dropping of the absorber rods. AERB asked KGS-2 to shutdown the reactor for investigation of the incident and taking corrective action to prevent recurrence of such incidents. Subsequently, the reactor was manually shut down and the affected absorber rod assemblies were removed from reactor core. Investigations revealed that in both the events, the absorber sub-assembly (having absorber) had detached from its retention support and dropped inside the reactor up to the retention support of lower absorber assembly. The cause of the detachment was identified as a manufacturing deficiency (i.e. improper installation of a lock pin), which was not detected due to inadequate quality assurance. All other absorber rod assemblies of same manufacturing lot in KGS-2 were replaced. However, the examination of the removed assemblies revealed that the penetration of lock pins in all other assemblies was adequate.

2.4.7. Authorization for Safe disposal / transfer of Radioactive Wastes for DAE Facilities under GSR-125

The disposal of radioactive wastes to the environment is governed by the Atomic Energy Safe Disposal of Radioactive Wastes Rules, 1987 (G.S.R.125). These rules are applicable to all the facilities generating radioactive wastes and provide the legal basis for regulation of safe disposal/transfer of radioactive wastes.

AERB issues the authorization for safe disposal / transfer of radioactive waste under the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules -1987 (GSR-125). These authorizations are valid for a period of maximum 3 years. Such authorizations for safe disposal / transfer of radioactive waste of forty two DAE facilities were valid up to 31st December 2015. Consequently these facilities submitted applications for renewal of authorizations as per the waste categorization specified in AERB Safety Guide "Classification of Radioactive Waste (AERB/SG/RW-1)". All these applications for renewal of authorization received from these facilities were reviewed in AERB.

Based on this review, authorisation for safe disposal or transfer of radioactive waste from forty one facilities were issued for a period up to December 31, 2018. Authorisation for safe disposal or transfer of radioactive waste from Indian Rare Earth Limited

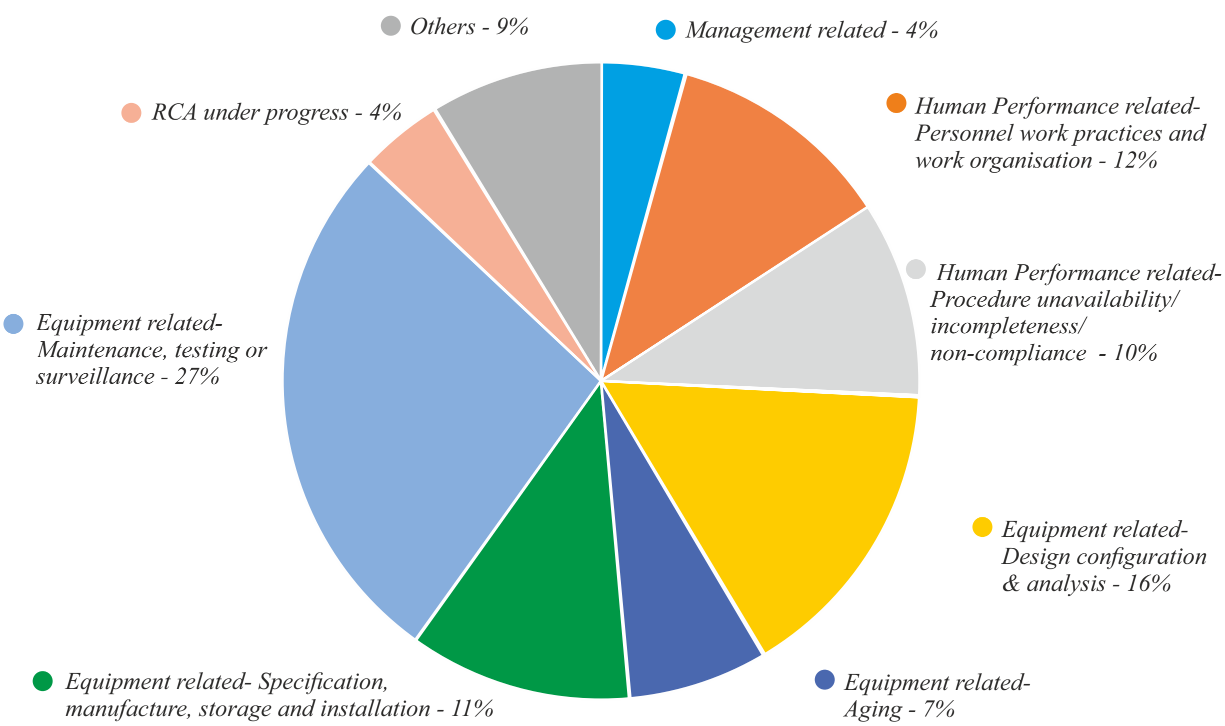


Figure-2.2: Classification of Root causes of SERs

Table –2.9: List of facilities for which authorisation were issued in 2015-16 for safe disposal /transfer of radioactive waste

S. No.	Name of DAE Organisation	No. of facilities
1	Uranium Corporation of India Ltd. (UCIL)	10
2	Indian Rare Earth Ltd (IREL)	03
3	Nuclear Fuel Complex (NFC)	05
4	Nuclear Power Corporation of India Limited (NPCIL)	14
5	IGCAR	05
6	Board of Radiation Isotopes Technology (BRIT)	04
7	Technology Demonstration Plant (HWB)	01
	Total number of authorizations	**42**

(IREL), OSCOM was approved for a period up to December 31, 2016 only as quantities and activity of radioactive waste from this facility is required to be established based on operating experience considering the expansion activities of the facility.

The number of units of various DAE organizations for which authorizations for safe disposal/transfer of radioactive waste were issued during the year 2015-16 is brought out in Table – 2.9.

2.5 NUCLEAR FUEL CYCLE AND OTHER RELATED INDUSTRIAL FACILITIES

2.5.1 Operational Safety Review:

The nuclear fuel cycle facilities and other related industrial facilities under the regulatory control of AERB are mines, ore processing and mineral separation plants of and Uranium Corporation of India Ltd. (UCIL) and Indian Rare Earths Limited (IREL), Nuclear Fuel Complex (NFC), Zirconium Complex (ZC), Heavy Water Plants (HWP), Atomic Minerals Directorate for Exploration and Research (AMD), Board of Radiation & Isotope Technology (BRIT) and some of the facilities at Indira Gandhi Center for Atomic Research (IGCAR). In addition to the above, Beach Sand Minerals (BSM) facilities and other facilities handling Naturally Occurring Radioactive Materials (NORM) are also regulated by AERB with respect to radiological safety aspects. The list of operating fuel cycle facilities and accelerators is presented in Table 2.10 and Table 2.11 respectively.

AERB continued its regulatory supervision of these plants. During the year 2015-16, applications for issuance/renewal of licenses submitted by Uranium Corporation of India Ltd. (UCIL) for Turamdih mill, Heavy Water Plants (HWPs at Manuguru, Talcher, Kota, Hazira and Baroda), CORAL facility of IGCAR, RAPPCOF facility of BRIT, Indus -2 Accelerator of Raja Ramanna Centre for Advanced Technology (RRCAT), Indore and Electronics Corporation of India Limited (ECIL), Beach Sand Minerals Plants were reviewed by AERB.

Number of meetings conducted by various safety committees / standing committees for operating fuel cycle facilities and other industrial facilities during the year 2015-16 is given in Table 2.12.

Table 2.12: Meetings of Safety Review Committees of Fuel Cycle Facilities

Name of the Committee	No. of meetings
UCIL-AMD Safety Committee	4
BSM-NORM Safety Committee	3
NFC Safety Committee	6
HWP Safety Committee	10
ECIL Safety Committee	1
DAE-Accelerator and Laser Safety Committee (DAE-ALSC)	2
IGCAR Safety Committee	2
Total	**28**

Table 2.10: Status of nuclear fuel cycle facilities in operation

Type of Facility	Name	Operated by	Functional Status	District/State	Scope of the Facility	Validity of Current License
Mines	Narwapahar	UCIL	In operation	Singhbhum(E) Jharkhand	Underground Uranium mining,	Renewal of license under process
	Turamdih		In operation	Singhbhum(E) Jharkhand	Underground Uranium mine	December 31,2018
	Banduhurang		In operation	Singhbhum(E) Jharkhand	Opencast Uranium mine,	June 30,2017
	Bagjata		In operation	Singhbhum(E) Jharkhand	Underground Uranium mine	June 30,2020 *(status as on June 2016)*
	Mohuldih		In operation	Singhbhum(E) Jharkhand	Underground Uranium mine	October 31,2019
	Tummallapalle		In operation	Y.S.R. Kadapa (Dist.) Andhra Pradesh	Underground Uranium mine,	February 28,2018
	Jaduguda		Shutdown	Singhbhum(E) Jharkhand	Underground Uranium mine	Statuotary Clearance from Forest Advisory Committee awaited
	Bhatin		Shutdown	Singhbhum(E) Jharkhand	Underground Uranium mine	Statuotary Clearance from Forest Advisory Committee awaited
	Chavara	IREL	In operation	Kollam(dist) Kerala	Mineral separation	August 19,2019
	Manavalakurichi		In operation	Kanyakumari (Dist) , Tamilnadu	Mineral Separation	August 19,2019
	OSCOM Chatrapur		In operation	Ganjam(Dist) Odisha	Mineral separation	August 19,2019
Ore Processing Facilities	Jaduguda	UCIL	In Operation	Singhbhum(E) Jharkhand	Uranium Ore Processing Mill	December 31,2020
	Turamdih		In operation	Singhbhum(E) Jharkhand	Uranium Ore Processing Mill	February 28,2018
	Tummalapalle		In Trial operation	Y.S.R. Kadapa (Dist.) Andhra Pradesh	Uranium Ore Processing Mill	December 31,2017

	OSCOM Chatrapur	IREL	In operation	GanjamDist, Orissa	Monazite processing	April 30, 2020
	Udyogamandal		In operation	Eranakulam (dist) Kerala	Rare earth Compounds and Uranium production	November 11, 2018
Nuclear Fuel Fabrication Facilities	NFC. Hyderabad	NFC	In operation	Hyderabad, Telangana	Fuel Fabrication • BWR Fuel Assemblies • PHWR Fuel Bundle- • PHWR fuel Assemblies	August 19, 2017
	Zirconium Complex	NFC	In operation	Pazhayakayal, Tamil Nadu	Reactor Grade Zirconium Sponge- 250 MT	June 30, 2017
Heavy Water Plants	HWP- Kota	HWB	In operation	Rawatbhata /Chittorgarh Dist./Rajasthan	Heavy Water production	December 31, 2017
	HWP-Manuguru	HWB	In operation	Telangana	Heavy Water production	June 30, 2020
	HWP- Baroda	HWB	In operation	Baroda/Gujarat	Tributyl phosphate (TBP) Potassium Metal	May 31, 2021
	HWP- Hazira	HWB	In operation	Hazira/ Surat/Gujarat	Heavy Water production	July 31, 2018
	HWP- Thal	HWB	In operation	Raigad/Maharashtra	Heavy Water production	December 31, 2019
	HWP- Tuticorin	HWB	In operation	Tuticorin/Thirunelveli Dist./ Tamil Nadu	Production of solvents TiAP- 3600 kg/year DHOA- 2850 kg/year D2EHPA-II- 2300 kg/year	March 31, 2017
	HWP- Talcher	HWB	In operation	Talcher/Angul Dist./Odiha	Production of solvents • Tri-Butyl Phosphate (TBP) • Enriched Boron ^{10}B Enriched Boron, • Di-2Ethyl Hexyl Phosphoric Acid (D2EHPA) • Tri Octyl Phosphine Oxide (TOPO) • Tri Alkyl Phosphine Oxide (TAPO) • Di Nonyl Phenyl Phosphoric Acid (DNPPA)	August 31, 2020
	TDP	HWB	In operation	Mumbai/Maharashtra	Crude Sodium diuranate	October 31, 2016

Table 2.11: Status of Accelerator Facilities

Type of Facility	Name	Operated by	Functional Status	District/State	Scope of the Facility	Validity of Current License
Particle Accelerator Research Facility (PARF)	Room Temperature Cyclotron (K-130)	VECC	Operation	Kolkata, W.B.	Heavy ion acceleration	August 31, 2017
PARF	Super Conducting Cyclotron (K-500)	VECC	Commissioning	Kolkata, W.B.	Heavy Ion Acceleration	No time limit
PARF	Medical Cyclotron Project	VECC	Equipment Erection	Kolkata, W.B.	Cyclotron machine along with 3 beamlines for production of radio-pharmaceuticals	January 31, 2017
LASER	150 TW Ti: Sapphire Laser System	RRCAT	Operation	Indore, M.P.	90 TW-for regular and 150 TW: trial (25 femto-second)	June 30, 2021
PARF	TWINDUS LINAC-2	RRCAT	Stage 1: Installation, Testing and Commissioning	Indore, M.P.	Electron Acceleration 10 MeV, 1kW	September 30, 2017
PARF	TWINDUS LINAC-1	RRCAT	Stage 3: Commissioning	Indore, M.P.	10 MeV, 5kW	January 31, 2017
PARF	20 MeV Microtron	RRCAT	Stage 1: Testing	Indore, M.P.	Electron Acceleration	February 28, 2017
PARF	Agricultural Radiation Processing Facility(ARPF)	RRCAT	Construction	Choithram Mandi, Indore, M.P.	Technology Demonstration for Food Irradiation	December 31, 2016

PARF	**INDUS-1** i) Microtron ii) Booster Synchrotron & iii)Synchrotron Radiation Source	RRCAT	Operation	Indore, M.P.	i) 20 MeV & 25 mA Electron Acceleration ii) 450 MeV/ 550 MeV electron Acceleration for injection in Indus1/ Indus2 SRS iii) 450 MeV, 100 mA electron Storage ring	August 31, 2018
PARF	**INDUS-2** i) Synchrotron Radiation Source (SRS) ii) Beamline (BL) 07 &16 iii) BL-09 iv) BL-08, 11 &12	RRCAT	i) Operation ii)Operation iii)Operation iv)Operation	Indore, M.P.	2.5 GeV, 200 mA SRS	i) March 31, 2021 ii) October 30, 2016(renewal under process) iii) November 30, 2018 iv)January 31, 2021
Accelerator	Electron LINAC	RRCAT	Operation	Indore, M.P.	10 MeV, 10 kW	January 31, 2018
Accelerator	1.7 MV Tandetron Accelerator	PIF, IGCAR	Operation	Kalpakkam, T.N.	1.7 MV	August 31, 2021
Accelerator	150 kV Accelerator	PIF, IGCAR	Operation	Kalpakkam, T.N.	150 kV	August 31, 2021
LASER	1 PW Laser system	RRCAT	Construction	Indore, M.P.	1 PW (femtosecond)	August 31, 2018

The highlights from safety review of the operating fuel cycle and other industrial facilities are given below.

(i) Uranium Corporation of India Limited (UCIL)

The mines at Narwapahar, Turamdih, Banduhurang, Bagjata, Mohuldih and Tummalapalle were under normal operation. Operations at Jaduguda and Bhatin Mine are under shutdown. The mills at Jaduguda & Turamdih were in operation during the year.

- The application for renewal of license for operation of Turamdih mill was reviewed by the UCIL-AMD safety committee and further by the next level of committee SARCOP, AERB. Based on satisfactory safety performance and the action plan for addressing the identified issues, the license for operation of Turamdih Mill was further renewed on February 29,2016 for a limited period of two year.

- The application for renewal of license for operation of Banduhurang mine was reviewed by the UCIL AMD Safety Committee and SARCOP. Based on satisfactory safety performance and the action plan for addressing the identified issues, the license for operation of Banduhurang Mine was renewed for a period of one year.

- The application for renewal of license for operation of Bagjata Mine was reviewed by the safety committee and SARCOP and based on satisfactory performance was renewed on November 30, 2015 for a period of five years.

- License for operation of Jaduguda Mill was renewed on December 09, 2015 for a period of five years.

- The proposal for setting up of second circuit of Effluent Treatment Plant at Turamdih mill was reviewed by UCIL Safety committee and SARCOP.

Following proposals are under review,

- Procedure for transportation of uranium concentrate produced at Turamdih mill of UCIL.

- Proposal for setting up of Magnetite (by-product) recovery plant at Turamdih mill.

- The proposal for AMD operations for the recovery of Niobium – Tantalum (Nb-Ta).

(ii) Indian Rare Earths Limited (IREL)

Rare Earth Division at IREL Udyogamandal and Mineral Separation Plants (MSP) of IREL at Chavara, Manavalakurichi and Chatrapur operated safely during the year. Operation license was granted to Monazite Processing Plant (MoPP) at IREL, Orissa Sand Complex (OSCOM), Chatrapur for limited capacity. The following proposals of IREL were reviewed:

- **Permission to set up 5.0 MLD Hybrid (SWRO-MED) Seawater Desalination Plant at IREL OSCOM**

  BARC & IREL (OSCOM) has taken-up a project to build 5.0 MLD hybrid Sea Water Desalination Plant (SWDP) at IREL, OSCOM premises to meet the freshwater needs of OSCOM as well as to demonstrate the field application of indigenous hybrid desalination technologies within the Department (DAE). The proposal was reviewed and a specialist group was constituted to look into siting and construction related safety aspects.

- **Proposal for processing monazite fraction through ilmenite circuit at IREL Chavara**

  The proposal for processing monazite fraction through ilmenite circuit at IREL Chavara was reviewed along with the radiological data generated during the trial operation. Based on the satisfactory review, permission was granted for processing monazite fraction through ilmenite circuit.

(iii) Nuclear Fuel Complex (NFC) & Zirconium Complex (ZC)

All the plants of NFC, Hyderabad and ZC, Pazhayakayal operated safely during the year. The following proposals of NFC were reviewed.

- The Site Emergency Preparedness Plan (SEPP) of Zirconium Complex was reviewed by NFC-Safety Committee of AERB and based on satisfactory review; the document was approved by AERB.

- **Siting & Construction consent for Pilot Plant for Characterization of uranium ore concentrates at New Uranium Oxide Fuel Plant-Oxide (NUOFP-O), NFC, Hyderabad**

  Application for siting & construction of Pilot plant for optimization of process parameter uranium ore concentrates and New Uranium Oxide Fuel Plant-Oxide at NFC Hyderabad was reviewed by NFC-Safety Committee of AERB and based on satisfactory review; consent for construction for these facilities was issued on November 12, 2015, which is valid up to November 30, 2018.

Following proposals are under review,

- **Magnesium Recycling Technology Development & Demonstration Facility (MRTDDF) at Zirconium Complex, Pazhayakayal and Demonstration Unit -1.5 Ton Zirconium Sponge at ZC, Pazhayakayal**

  Application for establishing Magnesium Recycling Technology Development & Demonstration Facility (MRTDDF) at Zirconium Complex, Pazhayakayal and Demonstration Unit -1.5 Ton Zirconium Sponge at ZC, Pazhayakayal is under review by NFC- Safety Committee.

- **Renewal of licence for operation of Zirconium Complex**

  The proposal for renewal of license for operation of Zirconium Complex is under review by NFC-Safety Committee.

(iv) Heavy Water Plants (HWPs)

The Heavy Water Plants operated safely during the year. Presently, HWP-Baroda is engaged in production of potassium metal and Tri Butyl Phosphate (TBP) solvent. Diversified projects namely, Versatile Solvent Synthesis Plant (VSSP) at HWP-Tuticorin and Versatile Solvent Production Plant (VSPP) at HWP-Talcher were under normal operation. The following proposals/safety issues were reviewed based on the multi tier review by safety committees:

- **Renewal of license for operation of HWP-Manuguru including Boron Facilities**

  License for operation of HWP-Manuguru was valid up to June 29, 2015. As per the regulatory requirement, HWP-Manuguru submitted the Application for renewal of license for operation of HWP-Manuguru along with Boron Facilities which was reviewed by AERB. Based on the satisfactory review of application and the action plan for addressing the identified issues, the license for operation of HWP-Manuguru was further renewed for a limited period of one year (up to June 30, 2016).

  AERB has asked HWP-Manuguru to submit design safety aspects w.r.t. raising height of Ash Pond–II, and completion status of hydro / pneumatic test of utility pipe lines, non-destructive tests (NDT) of the stagnant bottom dished ends and Residual Life Assessment (RLA) of exchange tower.

- **Renewal of license for operation of facilities at HWP-Talcher**

  License for operation of facilities at HWP-Talcher to produce Tri- Butyl Phosphate (TBP), Di-2 Ethyl Hexyl Phosphoric Acid (D2EHPA), Tri-Alkyl Phosphine Oxide (TAPO), Tri-Octyl Phosphine Oxide (TOPO) and Di-Nonyl Phenyl Phosphoric Acid (DNPPA), Control rod grade enriched Boron (10B) and enriched Boron (10B) was valid up to August 31, 2015. As per the regulatory requirement, HWP-Talcher submitted the Application for renewal of license for operation of its facilities which was reviewed by AERB. Based on the satisfactory safety performance of the facilities at HWP-Talcher, AERB renewed the License for Operation of facilities at HWP-Talcher for a period of 5 years (up to August, 2020).

- **Renewal of license for operation of HWP-Kota**

  License for operation of HWP-Kota was valid up to January 04, 2016. As per the regulatory requirement, HWP- Kota submitted the Application for renewal of license for operation of HWP-Kota which was reviewed by AERB. Based on the satisfactory review and the action plan submitted by HWP-Kota for addressing the identified issues, the license for operation of HWP-Kota was renewed for a limited period of 2 years up to December 31, 2017.

AERB recommended HWP-Kota to carry out assessment of one of the exchange tower for Fitness for Service beyond December, 2017, undertake structural stability & life extension study, Design Basis Report (DBR) for the envisaged engineering measures during hydrogen sulphide gas leak emergency and implementation of Engineering Control & Emergency Measures and to implement the Retrofitting Schemes for identified structures.

- **Renewal of license for operation of HWP-Hazira**

License for Operation of HWP-Hazira was renewed for a limited period of 2 years up to July, 2015. AERB had recommended that further extension of the license would be subject to the completion of the Structural Integrity Assessment of the plants and the Safety Assessment of HWP-Hazira w.r.t the external events and the review of these reports by AERB. HWP-Hazira has completed the above activities and the reports submitted by the plant were reviewed by AERB. Based on the satisfactory review and resolution of issues identified by AERB, the license for operation of HWP-Hazira was renewed for another 3 years i.e. up to July 31, 2018.

- **Approval of revised Technical Specifications for operation of facilities at HWP-Tuticorin and HWP-Baroda**

The revised Technical Specifications for the operation of HWP-Tuticorin and HWP-Baroda were reviewed and approved by AERB.

- **Renewal of License for Operation of TBP and Potassium Metal Plant at HWP-Baroda**

The proposal for renewal of License for operation of TBP and Potassium Metal plant at HWP Baroda was reviewed by HWP- Safety Committee and SARCOP, AERB.

(Based on satisfactory safety performance, license was issued on May 30, 2016 for further period of five years).

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

Exploration work at various sites of AMD in northern, southern, eastern, western, central and south central regions was in progress. Considering the low hazard potential these sites are inspected once in two years.

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

One application for renewal of license for operation and three applications with respect to enhancement of production capacity/ modification of license condition under the Atomic Energy (Radiation Protection) Rules, 2004 were reviewed by the BSM-NORM Safety Committee with respect to radiological safety aspects and disposal of monazite enriched tailings. Following licenses/registrations were issued to the BSM facilities as applicable for a period of five years.

- Registration certificate for operation of M/s Earth Mineral Resources (Pvt) Ltd. Unit –I, Sipcot, Industrial Estate, Tuticorin, Tamilnadu was renewed on 1st May 2015 for a period of five years.

- Registration certificate for operation of M/s Earth Mineral Resources (Pvt) Ltd. Unit –II, Sipcot, Industrial Estate, Tuticorin, Tamilnadu was renewed on 1st May 2015 for a period of five years.

- Registration certificate for operation of M/s Indian Ocean Garnet Sands Company Pvt. Ltd., Tiruchendur, Navaladi, Radhapuram, Tirunelveli, Tamilnadu was renewed on 1st May 2015 for a period of five years.

- Registration certificate for operation of M/s Manickam Minerals, Madathur, Tuticorin, Tamilnadu was renewed on 1st May 2015 for a period of five years.

- Registration certificate for operation of M/s Vetrivel Minerals (V.V. Minerals), Yellapetta, Gara Mandal, Srikakulam, Andhra Pradesh was renewed on 27th October 2015 for a period of five years.

(vii) Renewal of license for operation of CORAL Facility, IGCAR

The reprocessing of FBTR spent fuel is being carried out at CORAL (Compact Reprocessing of Advanced Fuels in Lead Cell) facility of IGCAR. AERB had accorded permission for operation of this facility up to March 2016 or completion of reprocessing of 14 Fuel Sub-Assemblies (FSAs), whichever is earlier. Accordingly, RpG, IGCAR submitted an application seeking extension of license for operation of the facility. The application was reviewed in detail by AERB through its multi tier review process. Based on satisfactory review of the application for renewal of license for operation and commitment given by IGCAR for addressing the identified issues, license for operation of CORAL was extended for limited duration i.e up to March 2017.However, the authorization for reprocessing of FBTR fuel pins with bum-up up to 155 GWd/t with a cooling period of not less than two years after removal from reactor is limited to 14 FSAs.

(viii) RAPPCOF, BRIT, Kota

Issuance of License for Operation of RAPPCOF

Board of Radiation & Isotope Technology (BRIT) fabricates Cobalt-60 sources at RAPP Cobalt Facility (RAPPCOF) to meet the demand in healthcare, industrial and agricultural applications. The radiological and operational aspects of this facility are reviewed in AERB on regular basis. AERB conducts routine regulatory inspections of the facility once in a year and special inspections as and when required. RAPPCOF obtained necessary approval /consent from AERB for implementing modification / change / augmentation in the facility.

RAPPCOF started fabrication of Cobalt Teletherapy Sources (CTS) for medical treatment in 2008 on campaign basis, based on approval from AERB. On recommendation of AERB, RAPPCOF submitted an application seeking license for operation of the facility under Atomic Energy (Radiation Protection) Rules, 2004. A detailed review of the RAPPCOF application was carried out in AERB. During the review of application, RAPPCOF was asked to identify the Postulated Initiating Events (PIEs) with respect to with operation of the facility & develop suitable measures/ contingency plans to mitigate the effect of the same and to develop an In-service Inspection (ISI) program for monitoring the healthiness of safety related SSCs of the facility. Pending the completion of these activities, the license for operation was of RAPPCOF issued for limited period up to July 31, 2016.

Permission for fabrication of Cobalt Tele-therapy Sources (CTS) at RAPPCOF

AERB had been giving permission for fabrication of CTS at RAPPCOF on campaign basis. The last such permission was granted in 2014 for fabrication of six CTS. Based on the review of the performance of facility during fabrication of these six CTS, AERB granted permission for fabrication of 24 more CTS in two batches of 12 CTS in each batch. On completion of fabrication of 24 CTS in 2015, RAPPCOF submitted application for fabrication of CTS on regular basis. This application was reviewed through a multi-tier safety committee of AERB. Based on satisfactory safety performance and considering the validity of the license for operation of RAPPCOF till July 2016, AERB agreed to permit fabrication of 40 nos. of CTS till July 2016. AERB decided that the permission for fabrication of CTS on regular basis would be considered as a part of reviews related to renewal of license for operation of facility beyond July 2016.

2.5.2 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 for fuel cycle facilities and DAE Accelerator units. During the year, a total of 99 inspections were carried out during the period that included 11 inspections with operating NPPs, 21 inspections with respect to nuclear power projects, 2 unannounced inspections at RAPPCOF and CORAL, IGCAR and 3 special inspections at IREL facilities, IGCAR facilities and NFC-Kota project. Scheduled inspections to cover aspects related to nuclear security were carried out at RAPPCOF and CORAL facilities.

2.5.3. Licensing of Plant Personnel

· The licensing committee for authorization/reauthorization of operation personnel of Heavy Water Plants met on four occasions and 32 operation personnel were authorized/ reauthorized during the year.

- The licensing committee for authorization/ re-authorisation of operation personnel of Nuclear Fuel Complex met on two occasions and 26 from Nuclear Fuel Complex and 23 operational personnel from Zirconium Complex were re-authorized during the year.
- The licensing committee for authorization/ re-authorisation of operation personnel (INDUS) of Raja Ramanna Centre for Advanced Technology (RRCAT) met on four occasions and 78 operation personnel were authorised/re-authorized during the year.

2.5.4 Significant Events

The following significant events reported were reviewed in detail by AERB and measures to prevent recurrence of such incidents were recommended.

- There was an event of discharge of effluent from Turamdih mill of UCIL into public domain in December 2015. According to the investigations carried out by UCIL, the leakage occurred due to crack in the temporary flexible hose which was deployed due to the choking of the regular Mild Steel Rubber Lined (MSRL) pipeline (used for transfer of liquor from sump to leach belt filter seal pot tank). Since the crack was close to the catchment bund, leakages lead to nearest drain in the plant. As an immediate corrective action, the flexible hoses were replaced by MSRL pipe and the crack in the bund has been repaired. UCIL has submitted the report of the local investigation committee. The incident was discussed in the AERB safety committees and it was noted that the root cause of the incident is lack of proper provision for flushing choked pipeline. AERB asked UCIL to establish the mechanism for flushing the choked pipeline with water after isolating the system and implement preventive measures at other vulnerable routes that may lead to discharge of untreated effluent.

- An incident of H_2S leakage from drain header took place on March 03, 2015 during pre-start-up of booster no. 1 at HWP, Kota. The root cause of the incident was identified as combined effect of thermal and alternative stresses, compounded by H_2S service over a period of time. The incident was reviewed by the HWP- Safety Committee of AERB. Presently, the portion of the affected pipeline has been replaced upto 6 m. The drain pipeline has been now made free from anchor points and laid in trench. The healthiness of the tee weld joint on the hookup point of casing and suction/discharge drains of booster compressor to the drain header was checked using dye penetrant test and it was confirmed that no noticeable degradation has been observed. Further detailed analysis of the cracked pipeline is in progress at BARC.

- An incident of acid leakage from HCl storage tank (No, 7114TK-11B) took place on September 02, 2015 at HWP, Kota. The root cause of the incident was identified as the failure of rubber lining between two rubber sheets' butt joint which could have caused localized corrosion and subsequent failure. The incident was discussed in the HWP-Safety Committee of AERB and recommendations were made to prevent recurrence of such events which included; implementing procedure for lapping of rubber lining over butt joints based on the IS 4682, enhancing frequency of inspection of repaired rubber lining of HCL tanks, adequate surveillance of transfer pump and ensuring proper Quality Assurance (QA), workmanship and supervision during rubber lining and providing additional acid storage tank for transfer of acid from affected tank.

- An incident of snapping of hook from the wire rope of 15 Ton under slung EOT crane took place on December 15, 2015 at HWP-Thal. The incident took place while making preparation for load testing of Zoola for carrying out shutdown maintenance jobs inside the tower. The crane maintenance was done before undertaking the job. The root cause of the incident was over travelling of the hook beyond the safe limit, leading to snapping to its snapping from rope due to pull by the hoist motor. This has occurred due to failure of limit switch/ or relay contact. There was no injury to any person working in the vicinity of the work area. The incident was reviewed by the HWP-Safety Committee of AERB and recommendations were made to prevent recurrence of such incidents including; establishing reliability and design life of the systems / components, increasing the frequency of periodic maintenance/ component replacement and incorporate additional safety systems in consultation with experts in EOT crane.

2.6 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) was also done by AERB apart from the Fuel Cycle Facilities. A two-tier review process is adopted for these facilities. The first level of review is by the respective unit safety committee of the facility and second level is by SARCOP.

2.6.1 Variable Energy Cyclotron Centre (VECC)

The Room Temperature Cyclotron (K-130) was under operation delivering alpha and proton beams of various energies and intensities. Commissioning of Super-conducting cyclotron & Radioactive Ion Beam facility are in progress. The civil construction of medical cyclotron, which will be used, for commercial production of Positron Emission Tomography (PET) and Single Photon Emission Computed Tomography (SPECT) isotopes, as well as high end technological research, is completed. Presently activities like installation of electrical services, HVAC system, clean room facility, sewage connection are under progress.

The following proposals related to VECC were reviewed in the DAE Accelerators & Lasers Safety Committee.

- **Safety Analysis Report & Status of activities at Medical Cyclotron Project**

  Medical Cyclotron project of VECC, Kolkata consists of production facilities for radio-isotopes for medical applications, Single Photon Emission Computed Tomography (SPECT) and F-18 (FDG) for Positron Emission Tomography (PET) as one part and other two parts are research and development related to Material Science and Accelerator Driven System. Safety committee reviewed the safety analysis report of the Medical Cyclotron project. Based on the review of the dose estimate calculated in the safety report, the committee recommended that the height of the stack shall be 25 meters from the ground level.

- **Permission for trial experiment in Radioactive Ion Beam Facility**

  Radioactive Ion Beam facility will be used for the research in the nuclear physics, nuclear-astro physics and condensed matter physics. The radioactive atoms will be produced in a thick target or multiple thin targets using very light ion beam from K-130 Cyclotron. The radioactive atoms diffusing out of the thick target will be ionized in an ion source for charge breeding. Presently ECR ion source, RFQ and three Linac (IH type) cavities have been commissioned and used for first acceleration test using stable ions from ECR ion source. After second Linac VECC has achieved 289.1 keV/nucleon energy and intends to commission Linac-3 from which it can get radioactive ion beam with energy of 413.9 keV/nucleon. The safety committee after detailed review recommended for the permission for trial experiment up to Linac-3 with 5 μA beam current.

2.6.2 Raja Ramanna Centre for Advanced Technology (RRCAT)

INDUS-1 Synchrotron Radiation Source was under operation with beam energy of 450MeV and beam current of 100mA delivering synchrotron radiation through five licensed beam lines. INDUS-2, which is a synchrotron cum storage ring, is under commissioning trials with beam energy at 2.5 GeV and a beam current of 150mA.Seven beam lines of INDUS-2 have already been authorised by AERB for carrying out experiments. The 10MeV Linear Accelerator (LINAC) at RRCAT was also under operation.

Status of ongoing accelerator projects such as Free Electron Laser (FEL)- LINAC, Infrared FEL-LINAC, 10 MeV TW-INDUS LINAC, 10 MeV Microtron, 2.5 MeV DC Accelerator at RRCAT, Indore and Agricultural Radiation Processing Facility (ARPF) at Choithram Mandi, Indore as well as laser projects are being periodically reviewed.

The following proposal related to RRCAT was reviewed in the DAE-ALSC.

- **Licence for Regular Operation of Indus-2 Accelerator**

  Proposal for licence for regular operation of Indus-2 Accelerator of RRCAT was reviewed by the DAE-Accelerator and Laser Committee of AERB and subsequently by SARCOP. Based on the detailed review of commissioning experience results and radiation surveillance data, Committee asked RRCAT to submit a note on implementation of Fault Tree Analysis Report, Safety factor in assessment of radiation dose, life time of beam at 2.5 GeV energy and 200mA beam current for further review by AERB before issue of licence for operation of Indus-2.

2.6.3 Electronics Corporation of India Limited (ECIL)

All the manufacturing Units of ECIL were in operation. The following proposal was reviewed in the ECIL safety committee:

- Application for the renewal of License for Operation of ECIL under the provisions of the Factories Act, 1948 and Radiation Protection Rules, 2004 was submitted by ECIL as per

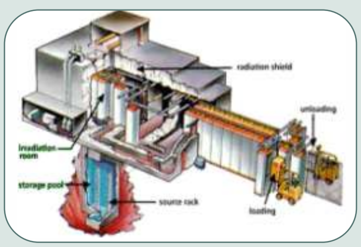

Chapter 3 Safety Surveillance of Radiation Facilities

3.1 INTRODUCTION

Radiation sources are being used in multifarious and ingenious ways to achieve overall societal health and prosperity. The radiation source implies radioisotopes (such as Ir-192, Co-60, Cs-137, Tm-170, Se-75 etc.) and radiation generating equipment like X-rays and Accelerators. The radiation sources have a wide range of applications in the industries, medicine, agriculture facilities and research institutions. These sources have the radiation hazard potential ranging from high to very low. Proper design, handling and disposal methodologies are required for ensuring safe and intended use of these radiation sources. The Atomic Energy Regulatory Board regulates the facilities/institutions using radiation sources in industry, medicine, agriculture and research. Regulation of these sources is in accordance with the radiation hazard potential involved and the extent of use in the public domain.

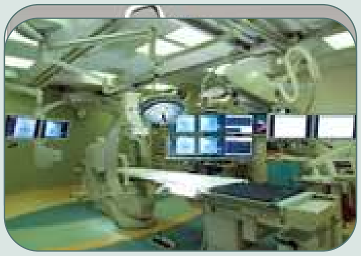
A glimpse on the various applications of these sources and their licensing status is as given below,

INDUSTRIAL APPLICATIONS OF RADIATION SOURCES

	Description	Number of facilities/ equipment licensed as on 31st March, 2016
RPF 	Radiation Processing Facilities (RPF) including Gamma Irradiators and Electron Beam Accelerators which are used mainly for radiation processing of food, sterilisation of healthcare products and crosslinking of polymers in cable industries. Radiation processing of food items includes inhibiting sprouting, delay in ripening, microbial decontamination, insect disinfestation, shelf line extension etc. The activity range is about few PBq. They are of high radiation hazard potential.	19 facilities
IRED used for 	Industrial Radiography using Industrial Radiography Exposure Device (IRED), is one of the important non-destructive (NDT) methods used for study of weld joints, castings etc. Radioisotopes like Ir-192, Co-60, Tm-170, Se-75 and different energies of X-rays are used in the field of industrial radiography. The activity range is from few TBq to few tens of TBq. The X-ray energy range is from few hundreds of keV to few MeV. They are of high to moderate radiation hazard potential	510 facilities with 2719 equipment
GIC 	Gamma Irradiation Chambers (GIC) are basically used for research & development and in irradiation of blood & blood components. Usually Co-60/Cs-137 radioisotopes are used in this application. The activity range from few tens of TBq - few hundreds of TBq. They are of high to moderate radiation hazard potential.	102 facilities with 121 devices

IRGD (also called Nucleonic gauges) 	The Industrial Radiation Gauging Device (IRGD) are used for online monitoring of quality control parameters such as thickness, level, density, coating thickness, elemental analysis etc. Sources used for nucleonic gauges consist of gamma sources such as Co-60, Cs-137, Am-241 etc., beta sources such as Sr-90, Kr-85, Pm-147, Tl-204, etc, and neutron sources such as Am-241-Be, Cf-252. The activity range is from MBq to GBq. They are of low radiation hazard potential.	1900 facilities
Well logging facilities 	Radioactive sources are used in well logging application for exploration of oil, coal, geophysical logging etc. The sources used are mainly Cs-137, Am-241-Be, some calibration sources such as Co-60, Ra-226, Th-232 etc. and neutron generators e.g. Deuterium-Tritium Generators. The activity range is from kBq to GBq. They are of moderate-low radiation hazard potential.	48 facilities 1520 sources
MEDICAL APPLICATIONS OF RADIATION SOURCES		
Tele-therapy 	In teletherapy (branch of Radiotherapy), radiation is used to treat malignancy. The radioisotopes like Co-60 and radiation generators such as Linear Accelerators are used. They are of high radiation hazard potential.	397 facilities with 588 teletherapy units
Brachytherapy 	In brachytherapy (branch of radiotherapy in which the source is kept very near to the lesion) the isotopes used are Ir-192, Cs-137, Sr -90, Ru-106, I-125 with activity range is MBq to GBq . They are of moderate hazard potential.	334 devices

Cath Lab



ComputedTomography

Radiography and Fluroscopy

X-rays are used in Medicine as an important diagnostic tool. Diagnostic Radiology using x-rays are:

- *Interventional Radiology equipment (Cath-Lab and C-Arm)*:
  These equipment are used in operation theatres for various interventional procedures and pose moderate radiation hazard to patients and medical professionals operating the equipment. The C-Arm equipment is of low to moderate hazard potential.

- *Computed Tomography (CT)*
  These equipment are of moderate hazard radiation potential to both worker and patient.

- *The general purpose radiography and fluoroscopy equipment and dental equipment:*
  These constitute around 70-80% of all x-ray equipment that are used and are of low to very low radiation hazard potential, to worker and patients.

- *Mammography, Bone Mineral Densitometer*:
  These equipment are of very low radiation hazard potential.

- 801 Cath lab equipment
- 1870 CT equipment
- 22481 other medical x-ray equipment

Nuclear Medicine Facilities

In Nuclear Medicine, radio-pharmaceuticals, such as Tc-99m, I-131, Tl-201 and F-18 are used for diagnosis and treatment. F-18 Radiopharmaceuticals are routinely used in PET-CT facilities, while I-131 is used for diagnosis and treatment of thyroid cancers. The facilities using pharmaceuticals are of moderate-low hazard.

236 facilities (PET-CT, SPECT and Gamma Camera)

Medical Cyclotron

Radio-isotopes that are used in Nuclear Medicine are generally produced in Medical Cyclotron facilities. The medical cyclotron facilities are of moderate- high radiation hazard potential.

15 facilities

Consumer Goods manufacturing facilities	Consumer goods such as smoke detectors, Thorium gas mantles and starters use exempt quantity of radioactive sources. They are of very low hazard potential. However, regulatory control exists on the manufacturing facilities of these devices.	15 facilities
Facilities using sealed sources	Though, sealed radioactive sources are used in various industrial and medical applications, but under this heading, sealed source means those that are used in education, research and calibration purposes. The activity range is from kBq to GBq. They are of low to moderate radiation hazard potential	257 facilities
Facilities using unsealed sources	Unsealed sources are used in various research and academic institutions, such as agriculture, veterinary science etc; They are of low radiation hazard potential.	213 facilities

3.2 REGULATORY METHODOLOGY

The regulatory methodology of the radiation facilities is based on the Atomic Energy (Radiation Protection) Rules, 2004 promulgated under the Atomic Energy Act, 1962. The regulation of radiation facilities, wherein all aspects of radiation hazard & radiation safety are addressed, are carried out broadly by a) Issuances of Consents b) Approval of Radiation safety personnel and c) Carrying out regulatory inspections and investigation of unusual occurrences, Apart from the above, AERB is also involved in conducting Awareness programmes and Accrediting/Recognizing institutes for environmental monitoring, low level counting and calibration of radiation survey meters & dosimeters.

3.2.1 Issuance of Consents

Consenting process involves the issuance of consent, in the form of License, Authorization or Registration (in the order of decreasing hazard potential), to operate the equipment / facility. Type Approvals are issued to manufacturer / supplier for equipment conforming to the regulatory standards. Approvals are also issued as an interim consent towards the respective Licenses. No Objection Certificates (NOC's) are issued to the stake holder to import either equipment or radioactive source, after which the stakeholder needs to obtain either a Type Approval or the respective consent for use. AERB has a multi-tier consenting process depending on the hazard potential involved. The process of issuance of various consents is as per AERB Safety Guide on 'Consenting Process for Radiation Facilities' (AERB/RF/SG/G-3).

The transportation of radioactive material (including that of nuclear material from nuclear facilities) is governed by regulations specified by AERB in Safety Code for the 'Transport of Radioactive Materials' and is in line with the international requirements specified by IAEA for safe transport of radioactive material.

The number of licenses and other consents issued during the year (April 2015-March 2016) is as follows:

CONSENT	PRACTICE	EQUIPMENT/ FACILITY/ACTIVITY	NUMBER ISSUED
LICENSE/RENEWAL	Radiotherapy	Linear Accelerator and Tele-cobalt	50
	Nuclear medicine	Medical Cyclotron facility	05
		PET-CT and SPECT-CT	38
	Diagnostic X-ray	Interventional Radiology	277
		Computed Tomography	841
		Manufacturing facilities of diagnostic X-ray equipment	11
	Radiation Processing Facility (RPF)		06
	Industrial Radiography Facilities		143
	Research Accelerators		02
AUTHORISATION	Radio therapy facilities	HDR Brachytherapy	18
	Radiation processing	Gamma Irradiation Chamber (GIC)	02
	Diagnostic X-ray facilities	Suppliers	18
		Service Agencies	33
	Well Logging		02
	Nuclear Medicine Facilities		363
REGISTRATION	Diagnostic X-ray facilities		12251
	Facilities using unsealed radio-isotopes for research		04
	Self-shielded X-ray unit and PCB analyzer		07
	IRGD (Nucleonic Gauges)		21
TYPE APPROVAL/ RENEWAL	Radiotherapy		11
	Interventional Radiology		06
	Computed Tomography		03
	Diagnostic Radiology		67
	IGRED (Industrial Gamma Radiography Exposure Device)		37
	Gamma Irradiation Chamber		-
	Sealed sources		-
	Industrial Radiation Gauging Devices (Nucleonic Gauges)		23
	X-ray baggage Inspection system		20

NOC's ISSUED FOR IMPORT OF EQUIPMENT	Medical Linear Accelerator	57	
	Tele-cobalt	05	
	RAL Brachytherapy unit	28	
	Radiation Processing Facility	00	
	Self-shielded x-ray unit and PCB Analyzer	00	
	IGRED	351	
	Diagnostic Radiology	76	
	Computed Tomography	12	
	Interventional Radiology	11	
PERMISISION FOR PROCUREMENT OF RADIOACTIVE SOURCE	**Type of practice**	**Indigenous**	**Imported**
	Industrial radiography	1050	111
	Well logging Sources	0	59
	IRGD	311	
	GIC	09	-
	Thorium Nitrate	04	-
	Thorium Oxide	01	-
	Consumer products(*Ionization Chamber Smoke Detector (ICSD), Electron Capture Detector (ECD), Ion Mobility Spectrometer (IMS), [Explosive Detectors], Static Charge Eliminator Device, Others (like watches/research associated products etc.)*	130	104
	Tele-cobalt source	26	05
	HDR Brachytherapy sources	-	334
	Nuclear Medicine	349	-
	Research Centres	336	-
DISPOSAL OF RADIO ACTIVE SOURCES (Permission for transport of radioactive material for safe disposal)	Exported to the original supplier	662 no. of sources	
	Disposal in authorized waste management facilities within the country	601 no. of sources + 255 Nos. of Tritium filled sources	

Other Approvals	Site approval	Medical cyclotron	0
		Radiation Processing Facility	9
	Layout plan	Radiotherapy	237
		Nuclear medicine centres	68
		Medical Cyclotron	00
		Industrial Radiography source storage facility	386

Other Approvals	Layout plan	Research centres	14
		Sources storage pit (well logging)	24
		Research accelerator	01
		Gamma Irradiation Chamber	07
	Design and construction	Medical cyclotron	01
		Research accelerator	00
		Radiation Processing Facility	00
	Commissioning	Radio-therapy Simulator	04
		Medical Cyclotron	00
		Medical Linear Accelerator (Radiotherapy)	40
		Tele-cobalt (new and after source replacement)	04
		RAL Brachytherapy Facilities (HDR)	12
		Industrial Radiography enclosure	131
	Decommissioning	Tele-cobalt units	06
		Remote after loading (RAL) brachytherapy unit	06
		Medical Linear Accelerator	09
	Source movement	Well logging	497
		IGRED	1210
		IRGD	08
	Source replacement /replenishment	Radiation Processing Facility	06
		Radiotherapy	138

3.2.2 Safety Committees for Radiation Facilities:

The safety committees review the radiation safety aspects of medical, industrial and research institutions which use radioactive sources / radiation generating equipment.

The committees also recommend issuance of license for operation or issuance of Type Approval, based on their review. The committees consist of experts in the field from the industry, medicine and academic institutions apart from the experts from Bhabha Atomic Research Center (BARC) and AERB.

Name of committee	Abbreviation	Number of meetings
Advisory Committee on Radiological Safety	ACRS	3
Safety Review Committee for Applications of Radiation	SARCAR	3
Safety Review Committee of Medical and Research Accelerators	SRCMRA	1
Safety Review Committee for Radiation Processing Plants	SRC-RPP	3
Committee on Safe Transport of Radioactive Material	COSTRAM	2
Committee on Safe Management of Disused Sources originating from Radiation Facilities	COSMDS	3
Standing Committee for Enforcement of Regulatory Actions in Radiation Facilities	SCERAF	3

Safety Committee on Nuclear Medicine Facilities	SACNUM	3
Safety Committee on BRIT Facilities	SCBF	5
Committee to Review Security Aspects of Radiation Facilities and Transport of Radioactive Material	CRSA-RF&T	2
Committee for Recognition of Calibration Laboratories for Radiation Monitoring Instruments	CRCL	2
Safety Committee for Review and Revision of AERB's Radiation Safety Documents	SC-RR-RSD	0
Committee to Review functioning and accreditation of Environmental Survey Laboratories (ESLs) at NPPs and other Radio Analytical Laboratories (RALs)	CORFAL	0
Committee for Accreditation Laboratories	CAPML	3

3.2.3 Approval of Radiological Safety Officers

While the built-in safety of the equipment and institution's operational preparedness towards safety are ensured by adhering to the requirements specified by AERB, the implementation of radiation safety is carried out by the AERB approved Radiological Safety Officers (RSOs). The RSOs are thus not only acting as extended arms of the regulatory body at every hospital and industrial radiation facility, but are also the pivotal interface between the medical/ industrial community and the regulatory body.

The number of fresh RSO's approved for different practices during the year are as follows:

Type of Practice	Number	Type of Practice	Number
Industrial radiography	576	Radiotherapy facilities	504
IRGD operations	292	Nuclear medicine facilities	170
Well logging operations	21	Research centers	40
Radiation processing facilities	3	Diagnostic radiology facilities	1242
GIC	14		

3.3 REGULATORY INSPECTIONS

One of the important means to ensure effective regulatory control in the use of radiation sources is through a structured regulatory inspection programme. AERB carries out inspections as laid down in its safety manual on “Regulatory Inspection and Enforcement in Radiation Facilities” (No. AERB/RF/SM/G-3, 2014). This documents covers all aspects of regulatory inspections such as frequency of inspections as per the graded approach, inspection process, enforcement actions, check list of various important parameters to be verified, the assessment on deviations etc.

Apart from the headquarters, its regional centers i.e. the Southern Regional Regulatory Centre (SRRC), the Eastern Regional Regulatory Centre (ERRC) and the recently instituted Northern Regional Regulatory Centre (NRRC) are mandated to carry out extensive regulatory inspections, covering the region. In addition, Directorate of Radiation Safety (DRS) / Radiation Safety Agency (RSA) at Kerala, Mizoram, Chhattisgarh, Tripura, Punjab and Arunachal Pradesh are authorized to carry out regulatory inspections for ensuring radiation safety of diagnostic radiology equipment installed in the respective states. The following are the inspections carried out in this year by AERB including the RRCs, DRS and RSA.

Type of facility	Type of inspection	No. of facilities/ institutes inspected	No. of equipment inspected
Radiotherapy equipment	Periodic	86	227
Medical cyclotron	Includes Site, Pre-commissioning and Periodic	2	0
Nuclear medicine facilities	Includes Site, Pre-commissioning and Periodic	93	
Diagnostic radiology	AERB	205	963
	Directorate of Radiation Safety, Kerala	424	797
	Radiation Safety Agency, Mizoram	41	77
	Directorate of Radiation Safety, Chhattisgarh	-	
	Radiation Safety Agency, Tripura	15	42
	Radiation Safety Agency, Arunachal Pradesh	7	10
Industrial radiography	Periodic and special	131	301
Radiation Processing Facilities	Includes Site, Pre-commissioning, Periodic and special	11	
Well logging facilities	Periodic	10	65
GIC	Periodic	15	18
IRGD	On sample basis	55	252
Manufacturer of gas mantles	Periodic	12	
Accreditation of Institutes	Pre-assessment	00	
Southern Regional Regulatory Centre	Radiation Facilities (Industrial and Medical Applications of Radiation)	50	
Eastern Regional Regulatory Centre		56	
Northern Regional Regulatory Centre		33	

3.4 UNUSUAL OCCURRENCES & ENFORCEMENT ACTIONS TAKEN BY AERB

Incident involving theft of two numbers of industrial gamma radiography exposure devices (IGREDs) model ROLI-1

An incident involving theft of two IGREDs models housing Ir-192 sources of activity about 0.15 TBq and 0.37GBq was reported to AERB on 10-07-2015 by an Industrial Radiography facility located in New Delhi. Theft of above IGREDs took place from their storage place at the office premises. The incident came into notice by the radiography personnel of the facility on 07-07-2015 and subsequently a complaint was lodged at the local police station. The above incident was transmitted to the concerned agencies of DAE by AERB as per established procedures along with preliminary investigation report for initiating further actions. The above theft incident is under investigation by the local Law & Enforcement Authority.

AERB issued show-cause notice to the concerned industrial radiography institution for committing violations of stipulated regulatory provisions and lack of physical security measures provided for radiography exposure devices during storage.

HIGHLIGHTS:

1) COMPLETION OF e-LICENSING OF RADIATION APPLICATIONS (e-LORA) PROJECT

As a part of its e-Governance initiatives, AERB has put into operation a one-of-a-kind web-based system called e-Licensing of Radiation Applications (e-LORA) which enables automation of the regulatory processes for various Radiation Facilities located across the country. The objective of the system is to ensure that procedures for application submission by the utility and application processing by AERB are simplified and fast as well as facilitates higher efficiency and enhanced transparency in its exchanges with the stakeholders. This is user-friendly and any stakeholder can view the status of their application for license on a 24 x7 basis. AERB has completed the development phase of e-LORA on December 31, 2015

With the implementation of eLORA, the response from the utilities and efficiency of AERB has significantly improved. The major achievement from the system is the quantum jump in the registration of X-ray equipment, which was the biggest challenge for AERB. So far, around 35,000 X-ray equipment has been declared in the e-LORA system of which, around 23,500 equipment are licensed. Apart from the increased ease, convenience and transparency for stakeholders, e-LORA has ensured proper inventory management of radiation sources in the country.

AERB was conferred the SKOCH Smart Governance Award 2015 during the 41st SKOCH Summit towards Transformative Governance in recognition of the successful implementation of the e-LORA.

Important milestones progression of eLORA project till the completion of development phase is given in Table-3.1 and the e-Forms developed is given in Table-3.2.

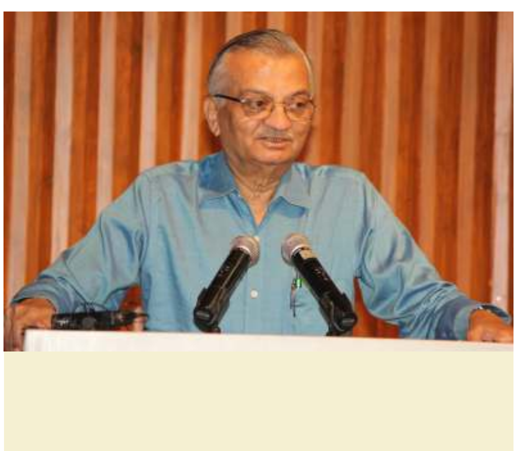
Apart from the above, eLORA Application-Internet Interface Module (IIM), and eLORA Application - Back Office Module (BOM), were also developed. eLORA has thus been successfully implemented. AERB has identified certain areas such as Integration of digital signature in approvals and Payment receive gateway in future developments of e-LORA.

2) ENFORCEMENT ACTIONS AGAINST ERRANT MEDICAL DIAGNOSTIC X-RAY FACILITIES:

AERB carried out inspections of medical diagnostic facilities at Mumbai, Navi-Mumbai, Jaipur, Nagpur, Raipur, Pune, Chennai, Bengaluru, Hyderabad, New Delhi, Kolkata, Patna, Ranchi, Gaya, Goa, and Ahmadabad.

As a part of the nation-wide campaign to ensure increased compliance and regulatory coverage of Medical diagnostic x-ray equipment, AERB carried out surprise inspection of these facilities in major cities/ towns in the country.

AERB has suspended operation of some of the medical diagnostic facilities at cities and towns across India in view of their non-compliance with the specified regulatory and radiation safety requirements.



Dr. Anil Kakodkar, Former Chairman, AEC, addressing the gathering during felicitation function of AERB for receiving the SKOCH Award

Table 3.1 : Evolution and development of eLORA project

Sr. No	Milestone	Date/Period
1.	Issuance of RFP (Request for Proposal) – a tender document	23/2/2011
2.	Award of contract	08/08/2011
3.	Project kick-off and Requirement Analysis started	September 2011
4.	Hardware delivery	January 2012
5.	Requirement analysis completion	September 2012
6.	FAT (Factory Acceptance Testing) completion	March 2013
7.	Hardware installation completion and start of FMS (Facility Management Services)	14/03/2013
8.	First module of eLORA (RP registration and institute registration along with BOM workflow) go-live	03/05/2013
9.	Revamping of existing website of AERB completion	17/07/2013
10.	First practice go-live (Radiotherapy)	12/08/2013
11.	Medical Diagnostic Radiology (1st Module) go-live	17/10/2013
12.	Complete go-live of Medical Diagnostic Radiology module	05/09/2014
13.	Industrial Radiography go-live	16/01/2015
14.	Gamma Irradiator Chamber go-live	23/01/2015
15.	Nuclear Medicine go-live	30/01/2015
16.	Well Logging go-live	30/01/2015
17.	Transport (non-DAE) go-live	30/01/2015
18.	Non-compliance Management go-live	08/05/2015
19.	Nucleonic Gauge go-live	29/05/2015
20.	Generic Supplier module go-live	29/05/2015
21.	Unusual Incident Management system	24/07/2015
22.	Excessive exposure management system	07/08/2015
23.	Consumer Product go-live	14/08/2015
24.	Research/RIA go-live	03/09/2015
25.	Industrial/Research Accelerator Facility go-live	23/09/2015
26.	Medical Cyclotron go-live	23/09/2015
27.	Gamma Radiation Processing Facility go-live	23/09/2015
28.	DRS module go-live	07/10/2015
29.	Transport go-live	28/10/2015
30.	Enforcement management go-live	04/11/2015
31.	Sealed source go-live	04/11/2015
32.	Calibration facility go-live	02/12/2015
33.	Closure of all development work	31/12/2015
34.	Start of 3 years of software AMC (Annual Maintenance Contract)	01/01/2016

Table-3.2: e-forms developed

Sr. No.	Practice/Module	Total no. of e-forms developed
1.	Calibration Practice	6
2.	Consumer Product Practice	6
3.	Diagnostic Radiology Practice	64
4.	Gamma Irradiation Chamber Practice	7
5.	Gamma Radiation Processing Practice	3
6.	Generic Modules	131
7.	IARPF Practice	6
8.	Industrial Radiography Practice	15
9.	Medical Cyclotron Practice	2
10.	Nuclear Medicine Practice	11
11.	Nucleonic Gauge	12
12.	Radiotherapy Practice	15
13.	Research and Sealed Source Practice	4
14.	Research Practice	7
15.	RIA Practice	5
16.	Transport Practice	12
17.	Well Logging Practice	12
	Grand Total	318

Before start of the campaign in April 2015, AERB had put out notices in various leading national dailies, directing utilities who have not yet obtained License /Registration, to come forward and first declare their x-ray equipment in the e-governance portal e-LORA, and within 6 months obtain the requisite License/Registration. The surprise inspections carried out at various cities/towns in the country, revealed that certain diagnostic x-ray facilities have still not complied with the regulatory requirements of AERB and accordingly requisite enforcement actions were taken against such facilities. The above actions taken by AERB received wide media attention.

Though the X-ray equipment are of low radiation hazard potential, it is important that they are installed and operated in accordance with the radiological safety requirements specified by AERB. AERB issues the requisite Licence/Registration after ensuring that they conform to the specified safety requirements.

3) STATUS OF DIRECTORATE OF RADIATION SAFETY (DRS)/ RADIATION SAFETY CELL/AGENCY

Directorate of Radiation Safety (DRS)/Radiation Safety Cell/Agency is established by State/Union Territory Governments after having a Memorandum of Understanding (MoU) with AERB. The purpose of formation of DRS/RSC/RSA is to strengthen regulation of X-ray facilities by decentralizing the regulatory inspection of the diagnostic radiology facilities utilizing X-ray units in various States/Union Territories of India. This step was taken for enhancing regulatory control over the large number of medical diagnostic installations using medical X-ray units in the country.

During the year, following progress was made towards establishment of DRS/RSA/RSC,

- Principal Secretary, Department of Health & Family Welfare, Government of West Bengal and Secretary, AERB signed the MoU for establishment of Directorate of Radiation Safety

Enforcement actions taken by AERB during surprise inspection campaign of Medical diagnostic x-ray equipment facilities in major cities/towns in the country

in the State of West Bengal on September 15, 2015.

- Authorization for functioning of Radiation Safety Agency (RSA) of Punjab was issued on May 8, 2015, subsequent to completion of training its staff by AERB on March 20, 2015.

- The RSA at Arunachal Pradesh was authorised to function on June 25, 2015, after completing the training programme of its staff.

- The validity of authorization for the Directorate of Radiation Safety of Kerala was extended till December 31, 2016.

- Workshop cum Training Program on e-Licensing of Radiation Applications (e-LORA) module for Diagnostic Radiology (DR) Practice was organized by AERB for Directorate of Radiation Safety (DRS) & Radiation Safety Agencies (RSA) in India from 28-09-2015 to 30-09-2015.

AERB has signed MoU with a total of 13 States (Kerala, Mizoram, Madhya Pradesh, Tamil Nadu, Punjab, Chhattisgarh, Himachal Pradesh, Gujarat, Maharashtra, Odisha, Arunachal Pradesh, Tripura and West Bengal) for establishing State Level DRS of which, DRS in Kerala, Mizoram, Chhattisgarh, Tripura, Punjab and Arunachal Pradesh are now functional.

4) DENTAL X-RAY EXAMINATIONS FOR AGE DETERMINATION

Following certain news reports regarding use of dental X-ray examinations with the aim of age determination or birth registration, AERB issued an advisory to medical/dental and the general public against indiscriminate use of dental x-ray examinations solely for the purpose of non-diagnostic applications such as age determination or birth registration. As the regulator for radiation safety in the use of medical x-rays for medical diagnostic applications, AERB considers such a practice as "unjustified".

5) ACTIONS TAKEN TO SECURE DISUSED SOURCES IN THE COUNTRY

Any radioactive source or equipment containing radioactive source which is lying in an unused condition for more than one year without any reasonable possibility of using it in the near future is considered a "disused source". This situation sometimes arises in certain hospitals, industries and research centres. Various factors for source to become disused are bankruptcy, non-availability of requisite manpower leading to non utilisation of the equipment etc. Such sources, especially if they are of high activity, become a safety concern owing to their possible neglect and likelihood of disposal of source in an unauthorised manner. To pre-empt such undesirable situations, these institutions are identified by AERB and are immediately directed to initiate process for decommissioning of equipment housing the source and its safe disposal by obtaining requisite consents for;

a) decommissioning of the equipment

b) transport of the source for safe disposal.

In the past, AERB had meetings with Board of Radiation & Isotope Technology (BRIT) (i.e source supplier) and suppliers of equipment to bring out possible solutions for decommissioning/ disposal of equipment held up owing to financial constraints. Similarly, AERB had meetings with Ministry of Health and Family Welfare and Department of Higher Education to address the decommissioning/disposal issues in certain hospitals/research institutions under the purview of the Government. Due to the persistent efforts of AERB, the number of institutions possessing disused sources has come down.

AERB continues to reinforce its regulatory inspections at institutions possessing disused sources, to ensure the safety of source while at the same time ensuring that the security arrangements at the institutions remain appropriate.

ATTENTION

All owners of Medical Diagnostic X-ray Equipment

Have you obtained Licence for operation of your X-ray equipment for ensuring radiation safety...?

☛ Operation of Medical X-ray equipment without AERB (Atomic Energy Regulatory Board) Licence is an offence under Atomic Energy (Radiation Protection) Rules 2004, promulgated under Atomic Energy Act 1962.

GOVERNMENT OF INDIA
ATOMIC ENERGY REGULATORY BOARD

Case File Number: DL-21374-RF-XL-007 — Issuance Date: 04/04/2016

Document Number: 16-LOEE-08226 — Expiry Date: 04/04/2021

LICENSE FOR OPERATION OF MEDICAL DIAGNOSTIC X-RAY EQUIPMENT

Type of Equipment	Manufacturer	Model	Equipment ID
Computed Tomography	M/s. Siemens AG	Somatom Definition	G-XL-44839

The Employer and Licensee are responsible for:

Note:
This Licence is issued ONLY from the RADIATION SAFETY VIEW POINT. All other clearances shall be obtained from concerned state/central/local authorities as applicable.

(Competent Authority)

MR. PRAVEEN GUPTA
SHRI BHAGWAN DIAGNOSTIC AND IMAGING CENTRE PRIVATE LIMITED
2116, BAWANA ROAD, NARELA NEAR SYNDICATE BANK
DELHI, DELHI-110040

Copy to: DIRECTOR, SHRI BHAGWAN DIAGNOSTIC AND IMAGING CENTRE PRIVATE LIMITED, DELHI

Choose between

Operating Licence

or

Sealing of X-ray equipment

☛ DO NOT DELAY – Several X-ray equipment have been sealed by AERB for operating without AERB Licence.

Licence can be obtained online through AERB's web application eLORA (e-Licensing of Radiation Applications) System.
Visit AERB website www.aerb.gov.in for more information

Message from **AERB**

Act Now – **E**nsure Radiation Safety – **R**egister in eLORA – **B**e assured

While undergoing prescribed medical X-ray examination, public is advised to ensure that X-ray equipment is Licensed by AERB

Issued by: **Atomic Energy Regulatory Board**
(Government of India)
Niyamak Bhavan, Anushaktinagar
Mumbai – 400094 (Maharashtra)

Chapter 4 Industrial Safety

AERB is responsible for administration of the Factories Act, 1948 and Atomic Energy (Factories) Rules, 1996 in all the units of DAE under its purview. AERB reviews the industrial and fire safety aspects during stage-wise consenting process, inspections and document development. AERB also focuses on the construction safety aspects of nuclear projects by carrying out special inspections of nuclear power projects in addition to the quarterly inspections of other nuclear facilities under construction. The fire safety aspects of the nuclear facilities are verified by checking the compliance with the requirements of AERB Safety Standard on "Fire Protection Systems for Nuclear Facilities" and periodic review of Fire Hazard Analysis of the facilities.

Licenses were issued/renewed under the provisions of the Factories Act, 1948 (as amended in 1987) and the Atomic Energy (Factories) Rules, 1996.

The nuclear power projects employ large number of contractor workforce, which is dynamic in nature and also there is a large spread of construction activities. In order to have an effective monitoring and to ensure highest level of industrial safety at these construction sites, special regulatory inspections on industrial safety were carried out once in six months.

Competent persons for various DAE units are appointed under the provisions of 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 Section (s) 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. During the financial year, sixty five persons were designated as competent persons in different DAE units.

Certifying Surgeons are appointed by AERB, under Section 10 of the Factories Act, 1948 (as amended in 1987) and under Rule 5 of Atomic Energy (Factories) Rules, 1996 for carrying out the duties prescribed in Rule 7 of Atomic Energy (Factories) Rules, 1996. During the financial year, six medical officers of various DAE units were designated as Certifying Surgeon.

A Fatal Accident Assessment Committee (FAAC) constituted by AERB reviews the fatal accidents at DAE units under the purview of AERB. The recommendations made by FAAC are further deliberated in respective Advisory Committees/SARCOP and Board of AERB. The lessons learnt are disseminated to all DAE units.

4.1 LICENSES ISSUED UNDER THE FACTORIES ACT, 1948 / ATOMIC ENERGY (RADIATION PROTECTION) RULES, 2004

The following licenses for operation under the Section 6 of the Factories Act, 1948 / Rule 3 of Atomic Energy (Radiation Protection) Rules, 2004, as applicable, were renewed/issued/extended to various DAE units under the purview of AERB.

- License for operation of HWP-Manuguru under Section 6 of the Factories Act, 1948 was renewed on June 29, 2015 for period of one year.
- License for operation of HWP-Hazira under Section 6 of the Factories Act, 1948 was renewed on July 28, 2015 for a period of three years.
- Licence for Operation of facilities at HWP-Talcher under Section 6 of the Factories Act, 1948 was renewed on August 20, 2015 for a period of five years.
- License for Operation of ECIL under Section 6 of the Factories Act 1948 was renewed on August 25, 2015 for a period of one year.
- License for operation of Bagjata Mine under Rule 3 of Atomic Energy (Radiation Protection) Rules, 2004 was renewed on November 30, 2015 for a period of five years.
- License for operation of Jaduguda Mill under Section 6 of the Factories Act 1948 and Rule 3 of Atomic Energy (Radiation Protection) Rules, 2004 was renewed on December 09, 2015 for a period of five years.

- License for operation of HWP-Kota under Section 6 of the Factories Act, 1948 was renewed on December 31, 2015 for a limited period of two years.

- License for operation of Turamdih Mill under Section 6 of the Factories Act 1948 and Rule 3 of Atomic Energy (Radiation Protection) Rules, 2004 was renewed on February 29, 2016 for a period of two years.

- License for Operation of Rajasthan Atomic Power Station 5&6 under Section 6 of the Factories Act 1948 was renewed on March 31, 2015 for a period of five years.

4.2 REGULATORY INSPECTIONS & SAFETY REVIEW

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

Special inspections at construction sites of nuclear power projects and quarterly inspections at construction sites of other fuel cycle facilities and R&D units were carried out to ensure compliance to the safety requirements stipulated by AERB. Quarterly industrial safety status reports from all major construction sites were reviewed by AERB.

During the year 2015-16, a total of 97 regulatory inspections were carried out which includes 21 inspections at construction sites of nuclear power projects, 6 special inspections at construction sites of NPP, 3 special inspection of fuel cycle facilities and 2 quarterly inspections of fuel cycle projects. These inspections were focused on implementation of various safety management systems related to the construction activities and compliance to the AERB Directives on construction safety. Some of the significant improvements observed at the operating plants and construction project sites are given below.

- Segregation of active and in-active wastes has been implemented in the Turamdih Mine of UCIL. Similarly, additional arrangement for transferring collected seepage water from waste dump to mine water treatment plant at Bagjata Mine of UCIL has been implemented.

- Electro-coagulation system has been implemented at NFC, Hyderabadfor treatment of non-process effluent to reduce uranium levels in the settling tanks.

- Periodic inspections, testing and maintenance programme has been implemented for the fire water system and fire detection systems at ECIL, Hyderabad.

- Periodic surveillance and preventive maintenance of the interlocks, alarm, siren and PA system has been implemented at RRCAT, Indore.

4.3 OCCUPATIONAL INJURY STATISTICS

The compilation of Occupational Injury Statistics-2015 of DAE units (other than BARC facilities and mines) provides the data on accidents and analysis of number of injuries and man-days loss.

During the calendar year 2015, there were 18 reportable injuries including two fatalities with a loss of 17,243 man-days compared to 29 reportable injuries including 2 fatalities with a loss of 22,120 man-days in 2014. The two fatalities during the calendar year 2015 occurred at construction site (RAPP 7&8) and R&D unit (IGCAR).

The year 2015 recorded a Frequency Rate (FR) of 0.13 as compared to 0.21 in the year 2014 and a Severity Rate (SR) of 122 as compared to 158 in 2014.

Incidence rates (IR) of DAE units are compared with that of similar industries across the country. The Non-fatal Incidence Rate in NPPs was 0.08 in 2015 as compared to 1.55 (2012) in other electricity generation companies in India. Non-fatal Incidence Rate in HWPs was 0.2 in 2015 as compared to 1.14 (2012) in other chemical manufacturing units in India. These figures, highlight better safety performance of some of the DAE units among 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.

In 2015, 370 Near Miss Accidents (NMAs) and 166 first aid injuries (non-reportable injuries) were reported from different units of DAE. There was no notifiable disease reported during the period from any of the operating units of DAE under the purview of AERB.

Unit wise comparison of reportable injuries and man-days lost in 2015 is presented in Figures 4.1 and 4.2 respectively. Unit-wise comparison of Injury Index and Frequency Rate (F.R) are given in Figures 4.3 and 4.4 respectively and year wise comparison of Injury Index in DAE Units is shown in Figure 4.5.

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 in Figures 4.6 to 4.8.

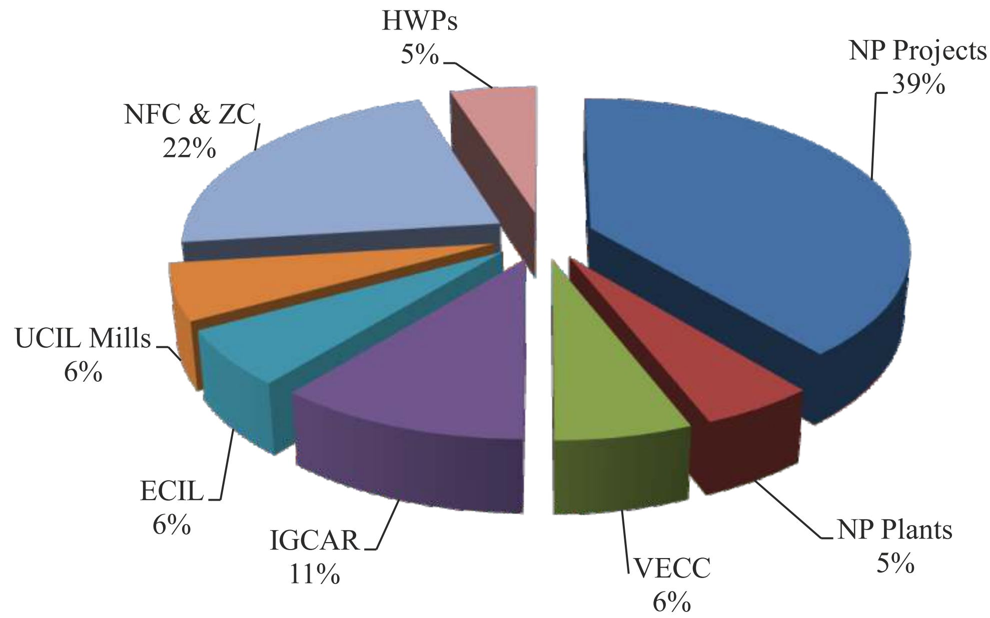


Fig. 4.1: Distribution of Reportable Injuries in DAE units in 2015

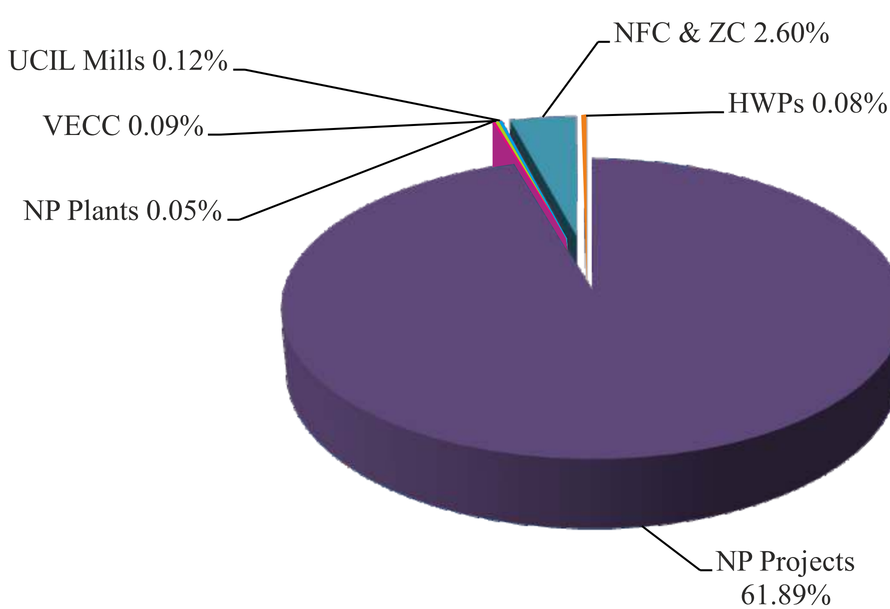


Fig.4.2: Distribution of Man-days Loss due to injuries in DAE Units in 2015

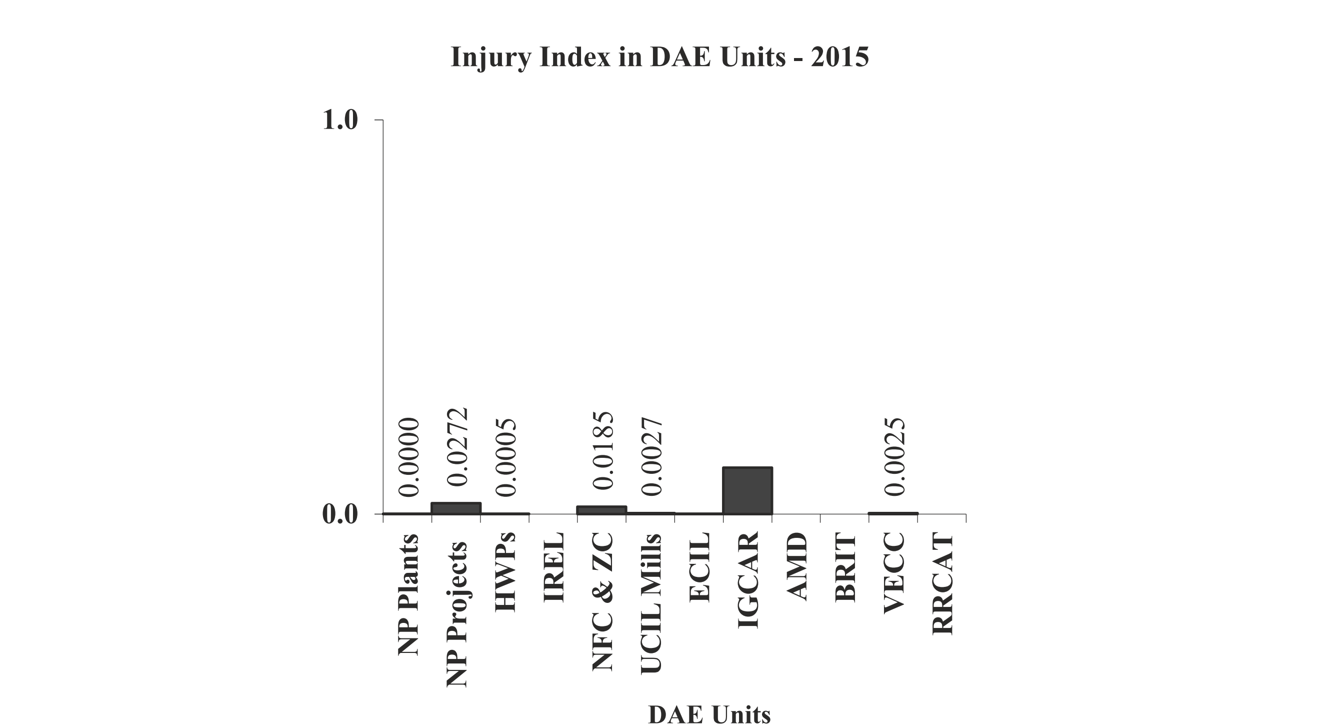


Fig. 4.3: Injury Index in DAE Units in 2015

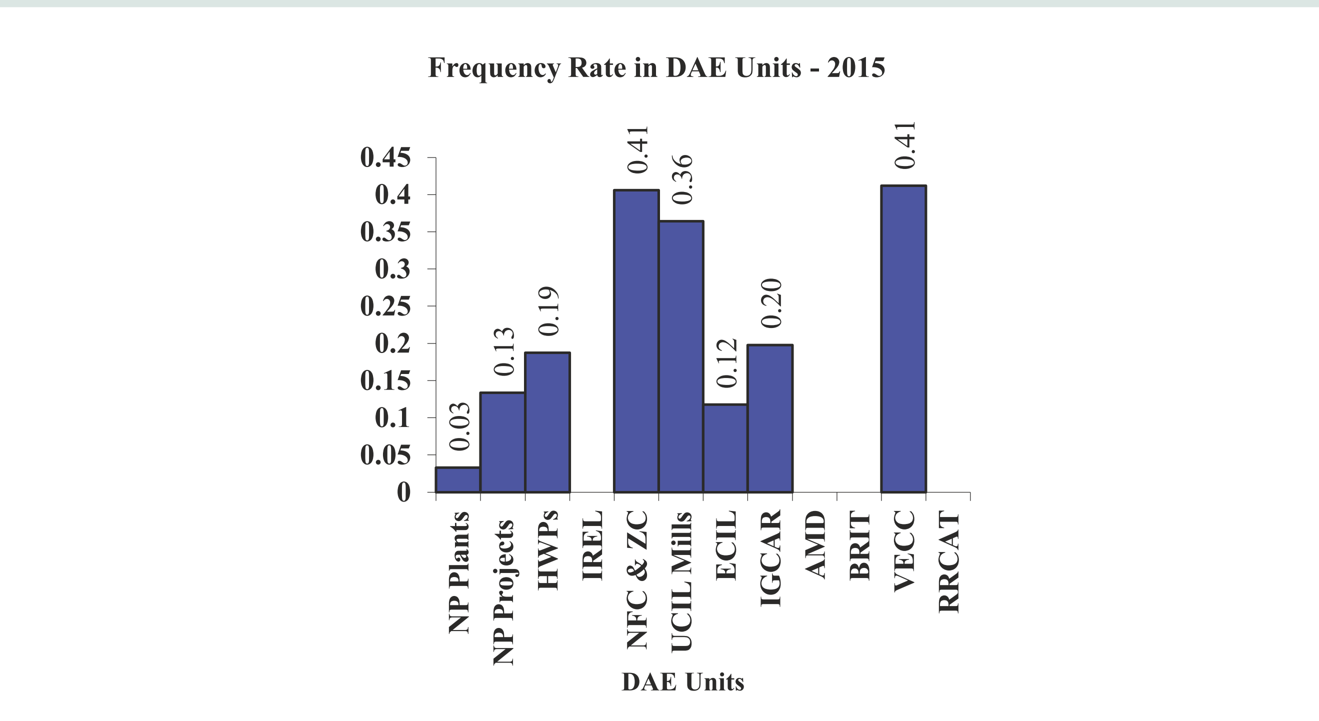


Fig. 4.4: Frequency Rates in DAE Units in 2015

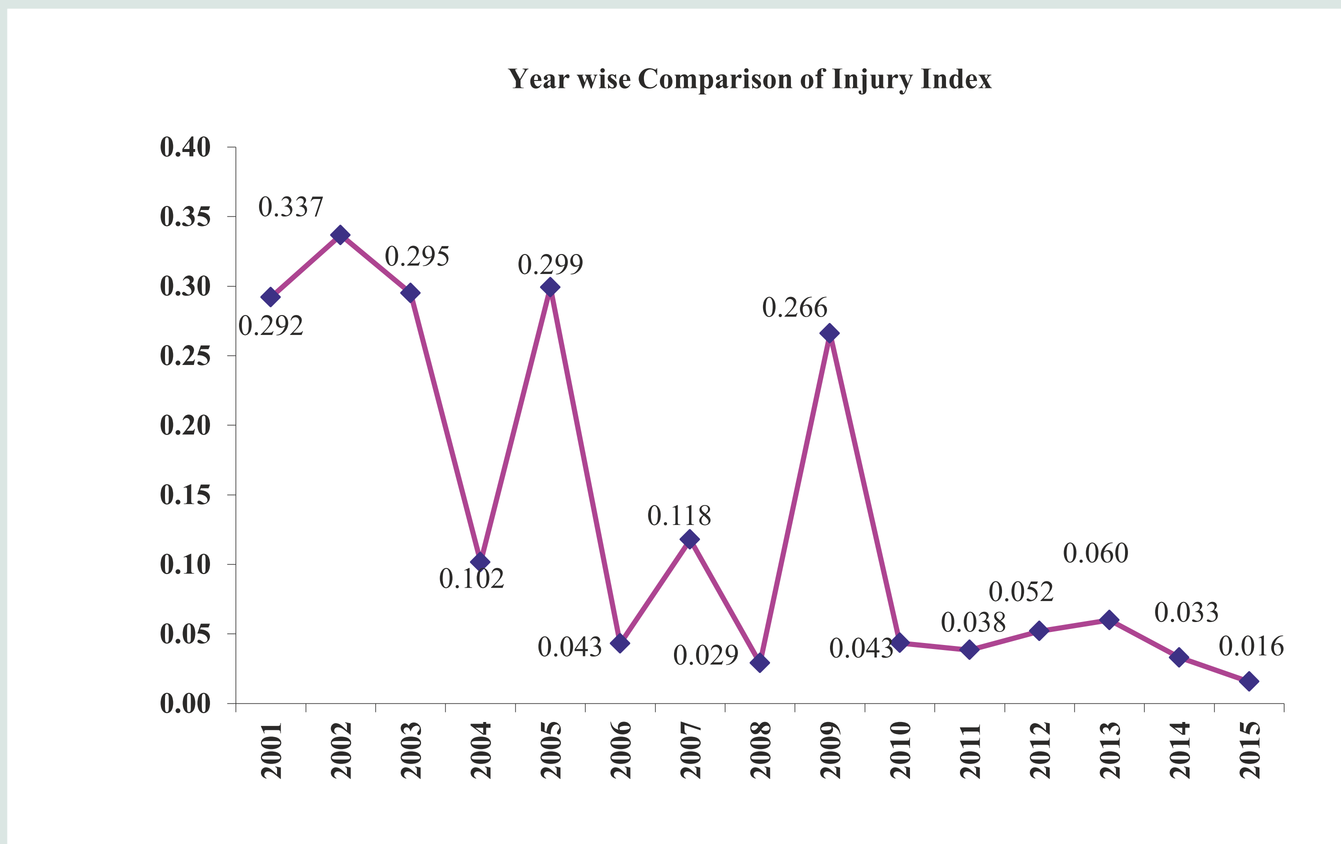


Fig. 4.5: Year wise comparison of Injury Index in DAE Units

Table 4.1: Comparison of Incidence Rates of DAE Units with Equivalent Non-DAE Industries (Data Source- Statistics of Factories -2012 published in January 2015, Labour Bureau, Ministry of Labour& Employment, Govt. of India)

Industry Type	Incidence Rate	
	Fatal	Non -Fatal
Heavy Water Plants (2015)	0	0.2
Manufacture of Chemicals & Chemical products (2012)	0.23	1.14
Nuclear Fuel Complex (2015)	0	0.92
Manufacture of Fabricated Metal Products except Machinery and Equipment (2012)	0.1	0.47
Nuclear Power Plants (2015)	0	0.08
Electricity, Gas, Steam and Air Conditioning Supply (2012)	0.33	1.55

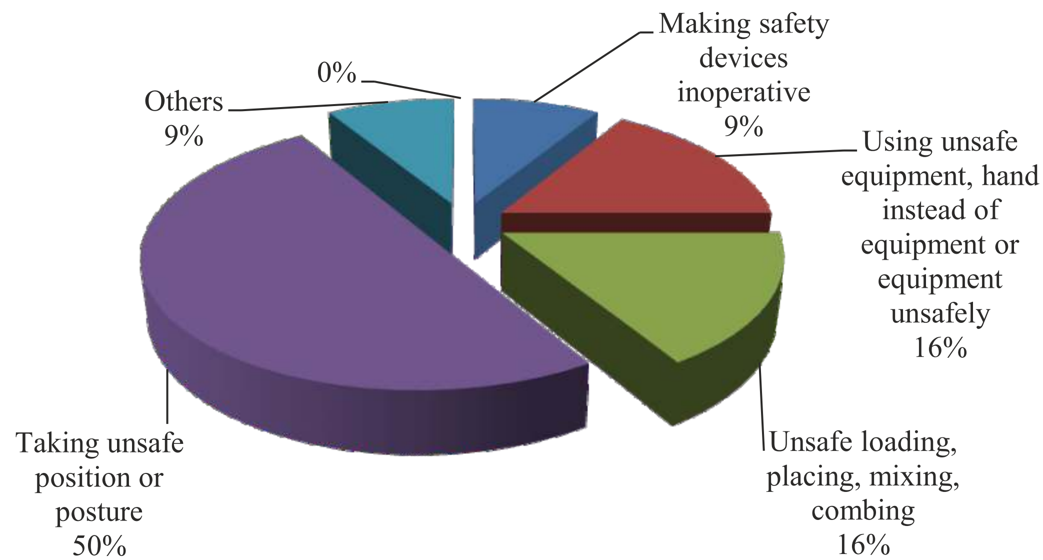


Fig. 4.6: Distribution of Injuries due to Unsafe Acts in DAE Units-2015

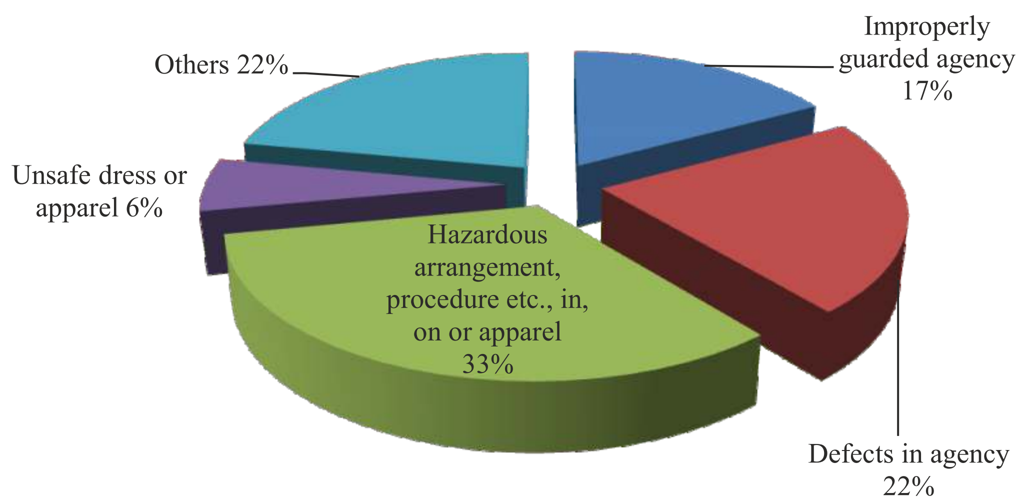


Fig 4.7: Distribution of loss time injuries based on Unsafe Conditions in DAE Units- 2015

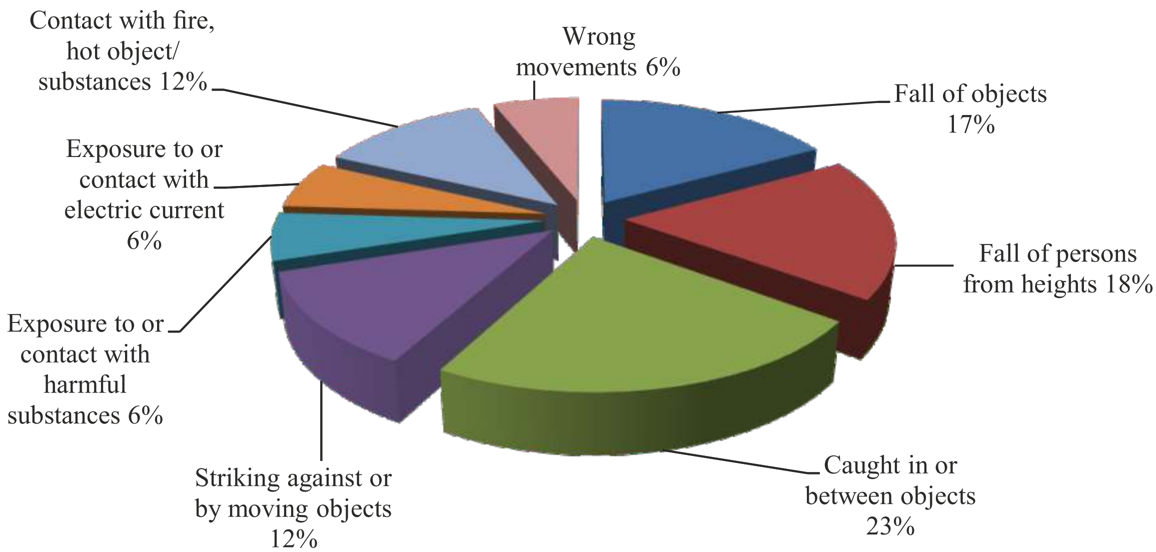


Fig 4.8: Distribution of loss time injuries with respect to Type of Accidents in DAE units-2015

4.4 FATAL ACCIDENTS

There were four fatalities at construction sites at IGCAR, Kalpakkam (one), RAPP 7&8 Project, Rawatbhatta (one) and NFC, Hyderabad (two) mainly due to fall from height. These accidents were investigated by AERB and reviewed by Fatal Accident Assessment Committee (FAAC) and recommendations were made to prevent such recurrences. The analysis and recommendations of these accidents were forwarded to all units of DAE for information and lessons to be learnt from these incidents.

A summary of the accidents along with review and recommendations/directives of AERB are given below.

- A fatal accident took place at Pyro Process Research and Development Facility (PPRD) of IGCAR, Kalpakkam on June 09, 2015.A contractor worker involved in carrying outthe job of welding of cross beams of the containment box (all the four sides) at 4m elevation fell from this elevation through the gap existing in partly erected containment box assembly. The victim was immediately brought to the First-Aid-Centre (FAC) and the On-duty medical officer after examining the victim declared him "brought dead". It is postulated that the victim might have lost balance while standing/sitting on the partly erected containment box panels or cross beams at a height of around 4m. Victim could have fallen directly through the gap (around 1m x 1.1m) existing in partly erected containment box assembly.

Following enforcement actions were taken by AERB.

- AERB suspended the construction activities at the Pyro Process Research and Development Facility of IGCAR and directed IGCAR to submit detailed investigation report along with road map for carrying out construction activities with required safety measures.
- The accident was reviewed by AERB and recommendations were made to prevent such accidents which included strict adherence to permit to work system, induction safety training to workers, provision of fall protection measures while working at height and strict enforcement of personal protective equipment.

- Based on the submission of compliance reports and review, AERB carried out a special inspection at the facility. In view of satisfactory compliance to the recommendations made by AERB and implementation of required safety measures by IGCAR, AERB permitted resumption of construction at PPPRD on October 10, 2015.

- A fatal accident took place at the construction site of RAPP-7 & 8 on December 28 2015. A contractor worker was allotted the job of tying the reinforcement rods with binding wires at common partition wall of Pipe & Cable Tunnel-93 and Cable Tunnel-62. After completing the tying of reinforcement rods on one row (from CTL-62 side), the victim tried to make a temporary working platform with two landing mats above a cantilever support of two pipes tied to reinforcement bars mesh. During the process of erection of working platform, the victim lost his balance and fell down from the temporary working platform. The victim received head injuries during the fall even though he was wearing helmet, as the surface was filled with hard debris and there were protrusions in the vicinity. The victim was immediately shifted to RAPS Hospital after administering first aid at first aid center and later shifted to Maitri Hospital, Kota for further treatment. However, he succumbed to his injuries on December 28, 2015 at 2110 hrs.

The accident was reviewed by AERB and recommendations were made to prevent such accidents which included, issuing of clear work specific instructions to workers before start of work, specifying hazard control measures in the work permit and verification of competency of personnel recruited by contractors by NPCIL.

AERB directed RAPP- 7 & 8 site to stop the construction activities till implementation of required safety measures at the construction site on January 8, 2016. Subsequently, AERB carried out special inspection of the site and based on the satisfactory implementation of recommended safety measures, AERB permitted resumption of the construction activities on January 21, 2016.

- On February 8, 2016, a roof slab which was being casted at the Zirconium Fabrication Plant (ZFP) expansion project site, collapsed, leading to two fatalities and eleven injuries. The contract for expansion of the ZFP bay by 108m was awarded to M/s V – Arks Pvt Limited. It was planned to cast the roof slab (at 10 m height) of the 15m wide high bay on February 8, 2016. During casting of the slab, a portion of the freshly laid slab collapsed due to the buckling of its formwork supports leading to the collapse of the entire roof slab. Eleven workers, one supervisor and works assistant present on the roof slab fell down from the roof slab. This accident led to the fatality of two contract workers and injuries to eleven contract workers.

Site immediately stopped all construction activities. The accident was reviewed by AERB and recommendations were made to prevent such accidents which included establishment of Quality Control in Civil Construction, deployment of adequate qualified supervisory staff to oversee the activities performed by the Contractors and strict adherence to the conditions of the safety work permit to ensure safety of workmen. Based on implementation of safety measures stipulated by AERB, site submitted a proposal for resuming the construction activities and was reviewed by the NFC-Safety Committee of AERB. Based on review, the committee recommended for resuming construction activities, except for the ZFP bay building at which the accident took place.

Chapter 5

Environmental Safety & Occupational Exposures

5.1 ENVIRONMENTAL SAFETY

The waste management aspects are reviewed throughout the life cycle of the plants, right from the siting stage, to construction, commissioning, operation and decommissioning stage. Based on the satisfactory review of the arrangements made by the plant for safe management of radioactive wastes, AERB issues Authorization under the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 with respect to the quantity and activity content of the waste.

AERB has specified the requirements for safe management of radioactive wastes in the Safety Code 'Management of Radioactive Waste (AERB / SC / RW)' and has issued several guides thereunder providing guidance on various aspects to meet the requirements of the Code. The Safety Code deals with the requirements for radiation protection aspects in design, construction and operation of waste management facilities and the responsibilities of different agencies involved. The Code is also applicable to the management of radioactive waste containing chemically and biologically hazardous substances, even though other specific requirements may additionally be applicable as per relevant standards.

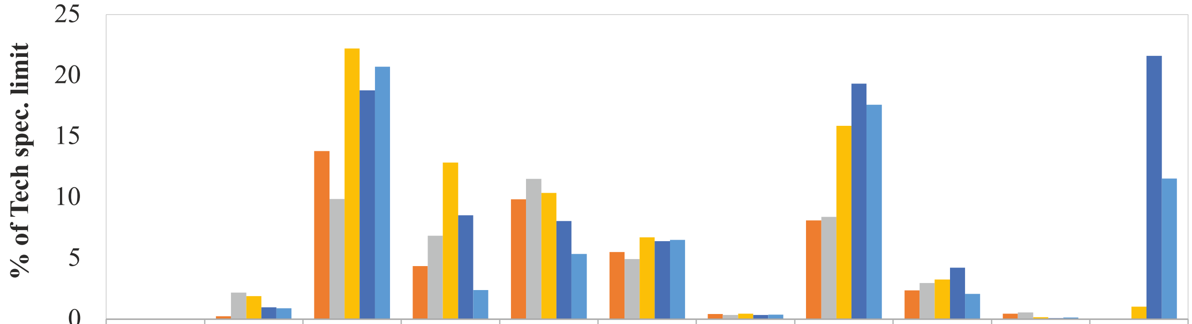
AERB has specified that the radiation dose to the members of public near the operating NPPs due to the discharge from the plants shall not exceed annual limit of 1 mSv (i.e 1000 micro-Sievert). This is in line with the limits recommended by International Commission on Radiological Protection (ICRP). Based on this limit, AERB has further specified limits on liquid and gaseous radioactive discharges through gaseous, liquid routes, in the Technical Specifications for operation of NPPs. These technical specification limits are set far below the dose apportionment to the public for the specific radionuclide. The radionuclide specific dose apportionment is small fraction of the annual dose limit (1mSv/year) to public. While specifying these limits, it is ensured that the discharge is controlled within public exposure limit of 1000 micro-Sievert following the principles of "As Low As Reasonably Achievable" (ALARA). In practice, the technical specifications limits are based on type of reactor, specific design features, operating experience on the effluent discharges feature etc., and giving consideration to ALARA principles. For example, in KKNPP Unit-1, small amount of tritium gets generated due to chemical addition in reactor coolant for which limit has been specified, however the limit is very small and the actual discharge from plant remains small fraction of the technical specifications limit.The limits specified in the technical specifications actually ensure that the dose to the public is well below the specified limit of 1000 micro-Sievert for NPP site. The actual discharges from the plants are seen to be well below the limits specified.

Periodic reports including effluent discharges are submitted to AERB in prescribed forms. AERB also conducts regular inspection of these plant sites to verify compliance with the laid down requirements. Every five years, prior to renewal of license for operation of these facilities, the adequacy of waste management arrangements, effluent release and their impact on the environment are thoroughly reviewed.

The independent Environmental Survey Laboratories (ESL) of the Health, Safety and Environment Group, BARC carry out environmental surveillance at all the operating nuclear power plants at sites.The liquid and gaseous radioactive wastes discharged to the environment during the year 2015 from the operating units were only a small fraction of the prescribed technical specification limits. The liquid and gaseous discharges from the plant for the year 2011, 2012, 2013, 2014 and 2015 as percentage of limits prescribed in technical specifications for operations of respective stations are presented in the Figures 5.1 (a) to 5.1(f).

Radiation dose to members of the public near the operating plants is estimated based on gaseous release and 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 the effective dose to public around all NPP sites is far less than the annual limit of 1mSv (1000 micro-Sievert) prescribed by AERB. The effective doses to members of the public due to the release of radioactive effluents from the plants are presented in the Figures 5.2 (a) & 5.2 (b).

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

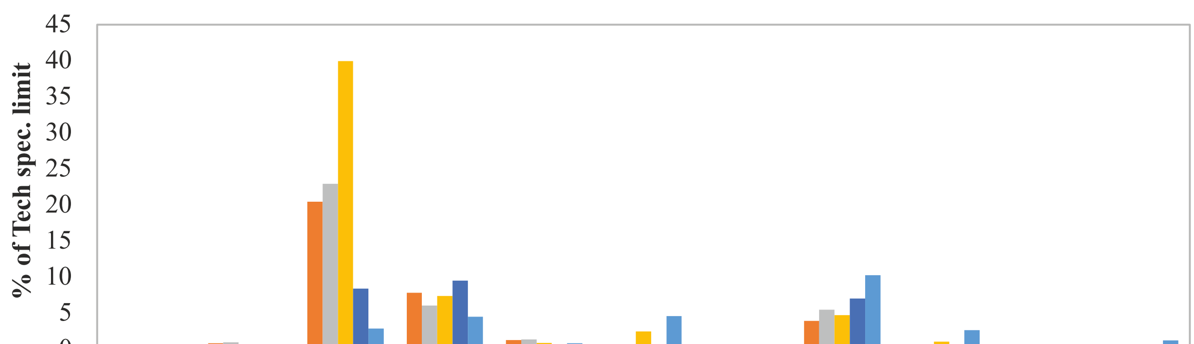


	TAPS 1&2	RAPS 1&2	MAPS 1&2	NAPS 1&2	KAPS 1&2	KGS 1&2	RAPS 3&4	TAPS 3&4	KGS 3&4	RAPS 5&6	KKNPP-1
2011	0.00	0.25	13.80	4.36	9.85	5.52	0.44	8.10	2.38	0.46	
2012	0.00	2.19	9.86	6.86	11.51	4.94	0.35	8.39	2.97	0.57	
2013	0.00	1.90	22.21	12.87	10.36	6.72	0.45	15.88	3.27	0.17	1.03
2014	0.00	0.99	18.78	8.54	8.07	6.42	0.35	19.34	4.22	0.079	21.62
2015	0.00	0.91	20.73	2.40	5.37	6.51	0.39	17.61	2.07	0.15	11.54

Note:

1) TAPS 1&2 are Boiling Water Reactors. Hence, there is no generation / discharge of Tritium.
2) The data of MAPS pertains to transfer of liquid waste to Centralized Waste Management Facility (CWMF) Kalpakkam for processing & discharge to the environment.
3) At KKNPP Unit-1, during operation of the reactor, a small amount of tritium gets generated. The station is authorized to discharge a miniscule amount of tritium through its effluent, after treatment. The authorized limits being very small, the discharges are reflected as significant percentage of authorized limit, even though the actual discharge amount is negligible from radiological safety considerations.
4) KKNPP-1 was commissioned in 2013, due to which data reported for KKNPP-1 is from 2013 only.

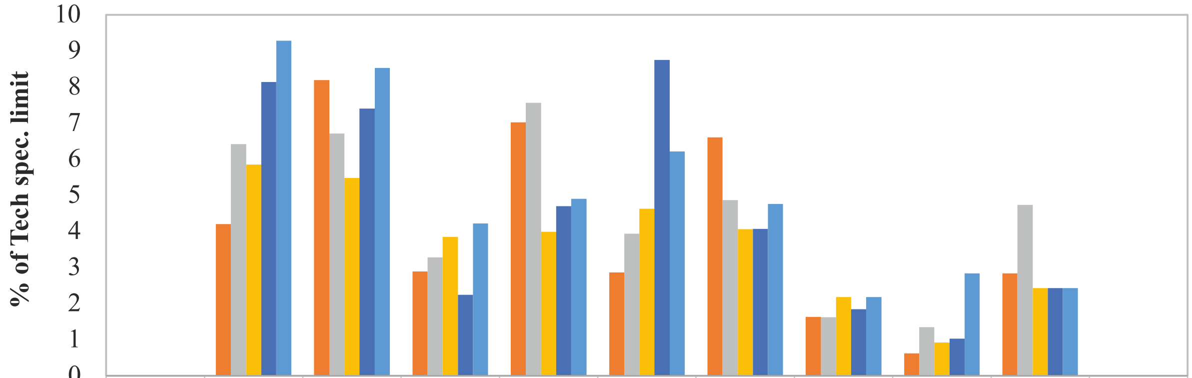
Fig 5.1 (b) : Liquid Waste Discharges from NPPs (Gross beta)



	TAPS 1&2	RAPS 1&2	MAPS 1&2	NAPS 1&2	KAPS 1&2	KGS 1&2	RAPS 3&4	TAPS 3&4	KGS 3&4	RAPS 5&6	KKNPP-1
2011	0.29	0.81	20.41	7.80	1.24	0.253	0.02	3.92	0.22	0.04	
2012	0.26	0.94	22.92	6.03	1.31	0.00	0.01	5.45	0.53	0.53	
2013	0.19	0.36	39.92	7.36	0.86	2.43	0.03	4.71	1.04	0.45	0.17
2014	0.18	0.24	8.39	9.48	0.50	0.29	0.02	7.01	0.11	0.11	0.31
2015	0.17	0.10	2.83	4.47	0.80	4.55	0.003	10.22	2.63	0.02	1.21

Note: Gross beta activity value reported by MAPS-1&2 is the activity transferred to CWMF of BARC. The Gross beta activity in liquid effluent release was high in the year 2013 as Unit-2 was shut down for 209 days.

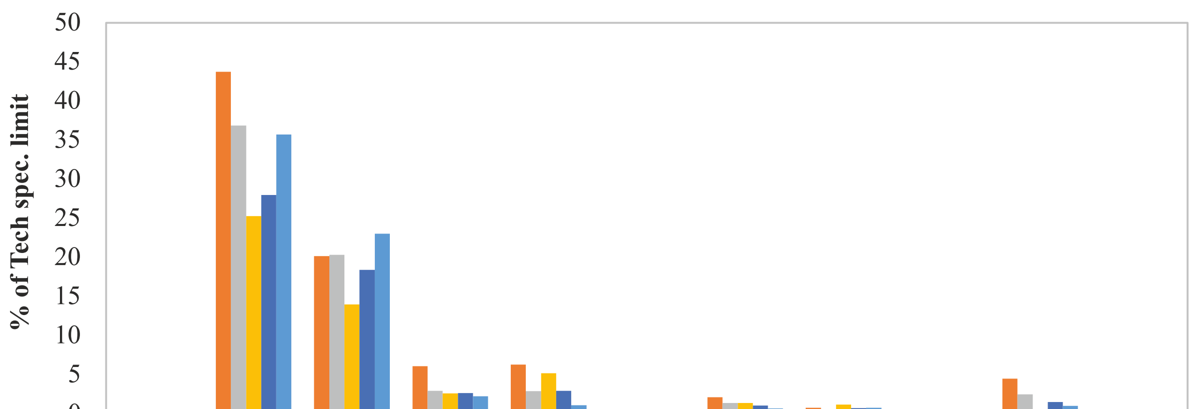
Fig 5.1 (c) : Gaseous Waste Discharges from NPPs (Tritium)



	TAPS 1&2	RAPS 1&2	MAPS 1&2	NAPS 1&2	KAPS 1&2	KGS 1&2	RAPS 3&4	TAPS 3&4	KGS 3&4	RAPS 5&6	KKNPP-1
2011	0.00	4.20	8.19	2.89	7.02	2.86	6.60	1.63	0.62	2.84	
2012	0.00	6.42	6.71	3.28	7.56	3.94	4.87	1.62	1.35	4.73	
2013	0.00	5.85	5.48	3.85	3.99	4.63	4.06	2.18	0.92	2.43	0.00
2014	0.00	8.14	7.40	2.24	4.70	8.75	4.07	1.84	1.03	2.43	0.00
2015	0.00	9.28	8.53	4.22	4.90	6.21	4.76	2.18	2.84	2.43	0.00

Note: TAPS 1&2 are Boiling Water Reactors. Hence, there is no generation / discharge of Tritium. KKNPP – 1 is PWR, there is no discharge of tritium through gaseous route.

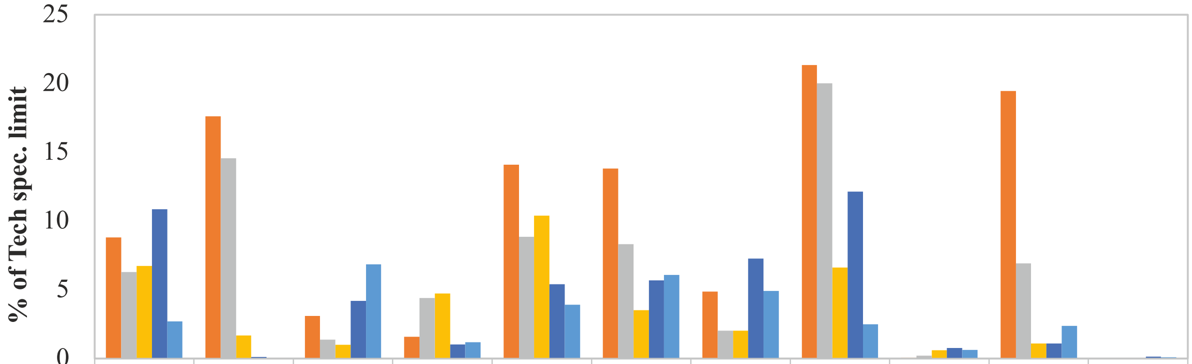
Fig 5.1 (d) : Gaseous Waste Discharges from NPPs (Argon-41)



	TAPS 1&2	RAPS 1&2	MAPS 1&2	NAPS 1&2	KAPS 1&2	KGS 1&2	RAPS 3&4	TAPS 3&4	KGS 3&4	RAPS 5&6	KKNPP-1
2011	0.00	43.72	20.16	6.06	6.26	0.06	2.12	0.74	0.12	4.46	
2012	0.00	36.86	20.33	2.91	2.88	0.00	1.35	0.54	0.08	2.48	
2013	0.00	25.29	13.98	2.61	5.18	0.00	1.37	1.14	0.34	0.50	0.00
2014	0.00	27.97	18.41	2.65	2.92	0.25	1.03	0.69	0.40	1.49	0.00
2015	0.00	35.69	23.00	2.24	1.08	0.14	0.68	0.76	0.01	0.99	0.00

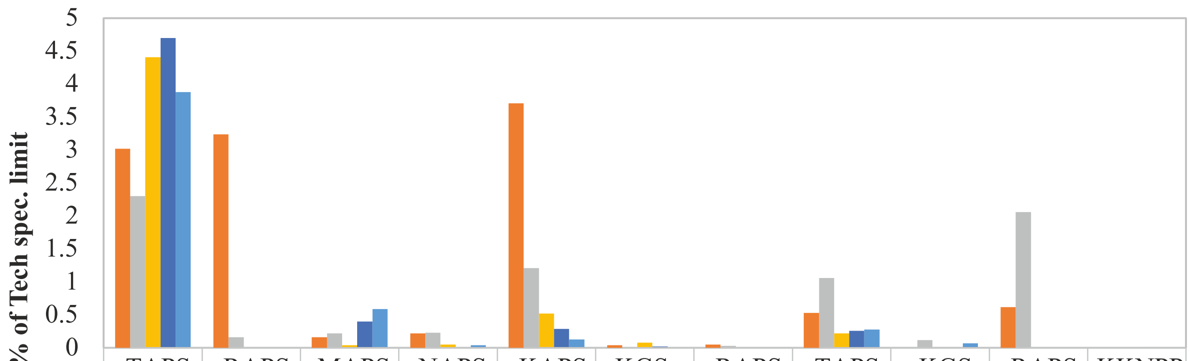
Note: Argon-41 release from RAPS-1&2 and MAPS are high as compared to other units due to air filled calandria vault and use of air for annular gas system.

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



	TAPS 1&2	RAPS 1&2	MAPS 1&2	NAPS 1&2	KAPS 1&2	KGS 1&2	RAPS 3&4	TAPS 3&4	KGS 3&4	RAPS 5&6	KKNPP-1
2011	8.79	17.60	3.09	1.58	14.09	13.82	4.87	21.33	0.03	19.45	
2012	6.29	14.55	1.36	4.40	8.84	8.32	2.03	20.00	0.20	6.91	
2013	6.72	1.66	0.99	4.73	10.38	3.50	2.03	6.62	0.59	1.09	0.002
2014	10.85	0.11	4.18	1.01	5.39	5.67	7.25	12.13	0.75	1.09	0.140
2015	2.69	0.00	6.85	1.17	3.91	6.07	4.90	2.48	0.61	2.36	0.08

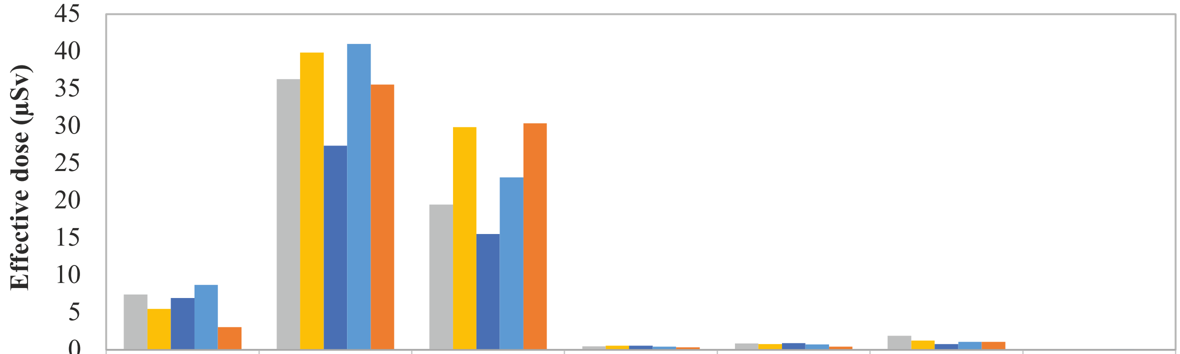
Fig 5.1 (f) : Gaseous Waste Discharges from NPPs (I-131)



	TAPS 1&2	RAPS 1&2	MAPS 1&2	NAPS 1&2	KAPS 1&2	KGS 1&2	RAPS 3&4	TAPS 3&4	KGS 3&4	RAPS 5&6	KKNPP-1
2011	3.02	3.24	0.16	0.22	3.71	0.04	0.05	0.53		0.62	
2012	2.30	0.16	0.22	0.23	1.21	0.01	0.03	1.06	0.12	2.06	
2013	4.41	0.00	0.04	0.05	0.52	0.08	0.00	0.22	0.00	0.00	0.00
2014	4.70	0.00	0.40	0.00	0.29	0.02	0.00	0.26	0.00	0.00	0.01
2015	3.88	0.00	0.59	0.04	0.13	0.00	0.00	0.28	0.07	0.00	0.0006

Note: In the technical specifications of TAPS-1&2, the limit for Iodine - 131 releases includesthe discharge of particulate activity also.

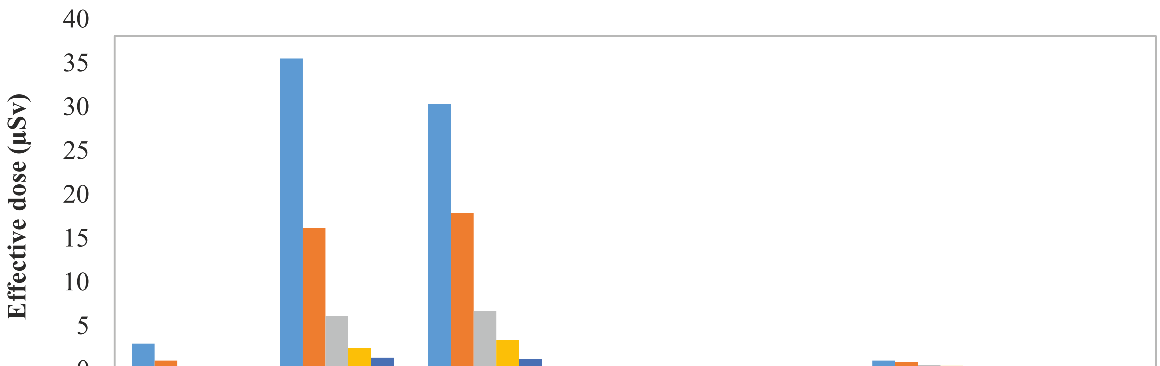
Fig 5.2 (a): Public Dose at 1.6 Km Distance for NPPs (AERB Prescribed Annual Limit is 1000 micro-sievert)



	Tarapur Site	Rawatbhata site	Kalpakkam site	Narora Site	Kakrapara Site	Kaiga Site	Kudankulam site
2011	7.42	36.30	19.50	0.48	0.88	1.90	
2012	5.52	39.88	29.88	0.56	0.78	1.24	
2013	6.94	27.40	15.52	0.56	0.92	0.8	0.001
2014	8.71	41.01	23.14	0.44	0.76	1.10	0.081
2015	3.04	35.58	30.39	0.36	0.42	1.10	0.022

Note: Public dose at Rawatbhata and Kalpakkam site is relatively higher as compared to other reactor sites, due to release of Ar-41 from RAPS-2 and MAPS.

Fig 5.2 (b): Total Effective Dose in Different Zones during the Year 2015 (AERB Prescribed Annual Limit is 1000 micro-sievert)



	Tarapur Site	Rawatbhata Site	Kalpakkam Site	Narora Site	Kakrapara Site	Kaiga Site	Kudankulam Site
1.6km	3.04	35.58	30.39	0.36	0.42	1.10	0.022
1.6-5km	1.08	16.24	17.94	0.25	0.28	0.90	0.006
5-10km	0.44	6.19	6.77	0.18	0.16	0.60	0.003
10-15km	0.26	2.54	3.44	0.16	0.14	0.50	0.001
15-30km	0.14	1.42	1.28	0.15	0.14	0.30	0.001

Note: Public dose at Rawatbhata and Kalpakkam site is relatively higher as compared to other reactor sites, due to release of Ar-41 from RAPS-2 and MAPS.

5.2 OCCUPATIONAL EXPOSURES

In each NPP, a Radiological Safety Officer (RSO) and Alternate RSO are designated by the Competent Authority to implement the radiation protection programme. The RSOs are entrusted with the responsibility for providing radiological surveillance and safety support functions. These include radiological monitoring of workplace, plant systems, personnel, effluents, carrying out exposure control, exposure investigations and 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 directives, 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 dose constraint for radiation exposure of temporary worker is 15 mSv.

For better exposure control, individual cases are investigated and controlled at an early stage so as to remain within the AERB specified dose limits. Following Investigation Levels (ILs) are applicable to the nuclear facilities.

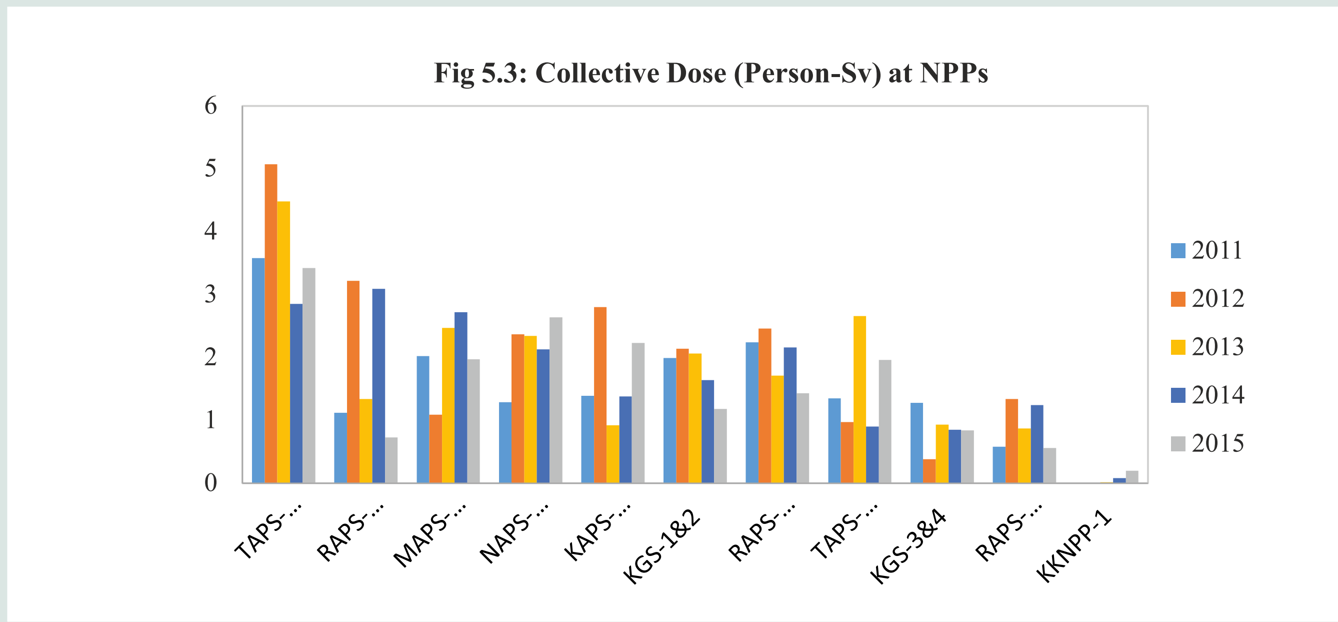
Monthly dose -10 mSv
Quarterly dose - 15 mSv
Annual dose -20 mSv

The information on number of workers in NPPs who received dose between 20 to 30 mSv and above 30 mSv during the year 2015 is given in Table: 5.1. In the year 2015, there was no case of individual radiation exposure above the prescribed annual dose limit of 30 mSv.

Table 5.1: Radiation Doses Received by Workers in NPPs (2015)

NPP	Number of monitored persons	Average dose for monitored person (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	1386	2.47	1103	3.10	1386	0	0
RAPS-1&2	923	0.80	569	1.30	923	0	0
MAPS-1&2	1326	1.49	1222	1.61	1326	0	0
NAPS-1&2	1348	1.96	1019	2.59	1348	0	0
KAPS-1&2	1431	1.56	1137	1.97	1431	0	0
KGS-1&2	1159	1.03	877	1.36	1159	0	0
RAPS-3&4	1465	0.98	1021	1.41	1465	0	0
TAPS-3&4	1564	1.26	1145	1.72	1564	0	0
KGS -3&4	1215	0.70	825	1.03	1215	0	0
RAPS 5&6	1159	0.49	798	0.71	1159	0	0
KKNPP-1	1940	0.10	334	0.61	1940	0	0

Figure 5.3 gives collective dose for operation and maintenance of NPPs for last 5 years



The information on number of workers in medical, industrial and research institutions who received various doses during the year 2015 is given in Table 5.2.

Table 5.2: Radiation doses (effective) received by workers in Medical, Industrial and Research Institutions during 2015* *(updated after excessive exposure investigation and receipt of more data)*

Category of radiation worker	No. of monitored persons	Averaged dose for monitored persons (mSv)	No. of persons receiving dose greater than zero	Averaged dose for monitored persons (mSv)	No. of workers receiving annual individual dose excluding zero dose D(mSv)		
					0<D<20	20<D<30	>30
Diagnostic x-rays	65268	0.33	25547	0.84	25522	20	5
Radiation Therapy	10548	0.23	4075	0.59	4073	1	1
Nuclear Medicine	2383	0.55	1391	0.95	1391	0	0
Industrial Radiography &Radiation Processing	7632	0.43	2344	1.41	2333	7	2
Research	4400	0.13	1354	0.43	1354	0	0
Total	**90231**	**0.33**	**34711**	**0.84**	**34673**	**28**	**8**

*Data (External dose) as on 30-4-2015 with National Occupational Dose Registry System (NODRS). The data does not include excessive exposure cases under investigation.

The information on number of workers in Medical, Industrial and Research Institutions, who exceeded radiation exposures in different ranges during the year 2014, was given in Table 5.2 of AERB annual report for the year 2014. The information for the year 2014 is now updated incorporating the outcome of investigation of excessive exposure cases that have been concluded and is given in Table 5.2 (a) below.

From the earlier reported cases in 2014, 591 more number of workers was assessed this year (primarily because of late receipt of TLDs from the institutions). The updated data also reveals that five additional workers received dose between 0-20 mSv and four additional workers received dose >50 mSv.

Table 5.2 (a) : Radiation doses received by workers in Medical, Industrial and Research Institutions during 2014* (updated after excessive exposure investigation and receipt of more data)

Category of radiation worker	No. of monitored persons	Averaged dose for monitored persons (mSv)	No. of persons receiving dose greater than zero	Averaged dose for monitored persons (mSv)	No. of workers receiving annual individual dose excluding zero dose D(mSv)		
					0<D<20	20<D<30	>30
Diagnostic x-rays	77295	0.33	32501	0.8	32473	21	7
Radiation Therapy	11931	0.20	4587	0.52	4587	0	0
Nuclear Medicine	2468	0.92	1634	1.38	1631	2	1
Industrial Radiography &Radiation processing	7408	0.53	2618	1.49	2605	6	7
Research	4028	0.15	1323	0.45	1323	0	0
Total	**103130**	**0.34**	**42663**	**0.83**	**42619**	**29**	**15**

*Data(External dose) as on 25/4/2016 with National Occupational Dose Registry System (NODRS). The data does not include excessive exposure cases under investigation.

The information on number of workers in various Fuel Cycle Facilities who received radiation doses less than 20 mSv, between 20 to 30 mSv and above 30 mSv during the year 2015 is given in Table 5.3.

Table 5.3: 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	156	0.7	1.05	156	0	0
	Bhatin	84	0.7	2.95	84	0	0
	Narwapahar	861	4.43	7.07	861	0	0
	Turamdih	655	3.5	8.19	655	0	0
	Bagjata	534	5.13	7.74	534	0	0
	Banduhurang	349	2.58	3.07	349	0	0
	Mohuldih	278	3.92	7.27	278	0	0
	Tummalapalle	1340	5.8	12.99	1340	0	0
Uranium mill (UCIL)	Jaduguda	1015	2.23	5.87	1015	0	0
	Turamdih	664	1.52	2.85	664	0	0
Thorium mines and mills (IREL)	Chavara	85	0.52	2.46	85	0	0
	Manavalakurichi	194	1.75	14.25	194	0	0
	Chatrapur	373	1.92	9.89	373	0	0
	Udyogamandal	317	1.55	24.77	314	3*	0
Fuel fabrication (NFC)	Hyderabad	1354	0.79	7.2	1354	0	0

*Three workers engaged in thorium oxalate slurrying and pumping received dose above the investigation level of 20 mSv (21.73, 23.61, 24.77) and these cases were properly investigated.

Chapter 6 Emergency Preparedness

Nuclear Power Plants (NPPs) in India are designed, constructed, commissioned and operated in conformity with relevant nuclear safety requirements. These requirements ensure an adequate margin of safety so that NPPs can be operated without undue radiological risks to the plant personnel and members of the public. State of the art safety measures are provided based on principles of defense-in-depth, redundancy (more numbers than required) and diversity (back-up systems operating on different principles). These include fail safe shutdown system to safely shutdown the reactor, combination of active and passive (systems working on natural phenomena and not needing motive power or operator action) cooling systems to remove the heat from the core at all times and a robust containment systems for confining any release of radioactivity. Not withstanding these, it is mandatory to develop Emergency Preparedness and Response (EPR) Plans as a measure of abundant caution. These plans are prepared in accordance with the national laws and regulations and deals with the effective management of any eventuality with a potential to pose an undue radiological risk to the plant personnel and public.

Similarly, EPR plans are ensured for nuclear facilities under the purview of AERB handling hazardous chemicals namely ammonia and hydrogen sulphide based Heavy Water Plants (HWPs) and some of the heavy water plants catering to the production of solvents. These plans are prepared as per AERB safety guidelines on 'On-Site' and 'Off-Site' Emergency Preparedness for Non-nuclear installations and deals with the effective management of any eventuality with a potential to pose an undue chemical risk to the plant personnel and public.

AERB reviews and approves the emergency preparedness and response plans for both plant and on-site emergency situation whereas off-site emergency plans are reviewed by AERB and approved by the District Authority / Local Government. Site-specific emergency preparedness plans of the respective stations are tested by carrying out periodic emergency exercises involving the station authorities, district administration, and the members of public on sample basis. These exercises are used for twin purposes:

a) Familiarization of personnel concerned with the management and implementation of emergency response and protective measures and

b) Assess the adequacy of these plans and improve them based on feedback from exercises. 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 two years respectively. During the periodic regulatory inspections of NPPs, AERB reviews the preparedness of plants to handle emergencies to verify that this is in accordance with the approved plans.

Periodic Site Emergency Exercises (SEE) and Off- Site Emergency Exercises (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, Periodic Emergency Exercises (PEEs) & Fire mock exercises are carried out at ammonia based HWPs at Baroda, Thal, Hazira and Talcher. PEEs are carried out once in a quarter and fire mock exercises are carried out once in 2 months.

The number of site and off site emergency exercises carried out at NPP sites in 2015 is given in Table 6.1. AERB officials witnessed site emergency exercises at six stations and offsite emergency exercises at four sites. The OSEEs at Rawatbhata Rajasthan Site and Kakrapar Gujarat Site are scheduled during the year 2016 to regularise their OSEE calendar (These sites conducted two OSEEs in consecutive years 2010 & 2011 and subsequently in the year 2013).

Table 6.1: Site and off-site emergency exercises carried out in the year 2015

NPP Sites	SEE	OSEE
Tarapur Site	1	1
Rawatbhata Site	1	0
Kalpakkam Site	1	1
Narora Site	1	1
Kakrapar Site	1	0
Kaiga Site	0	1
KKNPP	1	0

Review of Preparedness for Site and Off-Site Emergency at NPP Sites

AERB conducted regulatory inspections to check the emergency preparedness at all NPPs. AERB officials carried out special regulatory inspections on emergency preparedness aspects and participated in Offsite emergency exercise as observers at four NPP sites, viz. Tarapur, Kalpakkam, Narora, and Kaiga. AERB officials also witnessed site emergency exercises at six NPP sites, viz. Kakrapar, Rawatbhata, Kudankulam, Tarapur, Kalpakkam and Narora. These OSEEs were in general satisfactorily and in line with the approved emergency preparedness and response plans. The observations made during these exercises and inspections were sent to stations for implementation of the corrective actions. The coordination among plant personnel, district officials and public involved in these exercise was good and their response / action were timely. The observer's reports on these off site emergency and their findings are being discussed in AERB for appropriate corrective actions and guidance. Few of the identified issues discussed in SARCOP include the non-participation of all the identified district official in exercises, identification of alternate for all the identified district official, harmonization of emergency preparedness plans and to make these in line with latest revision of AERB/NRF/SG/EP-5 (“Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency”), conducting off site emergency exercises for covering all the sectors and all the response functions in periodic manner.

AERB Observer at Traffic Diversion Point at NAPS

AERB Observer at Offsite Emergency Control Centre (TMS, Tarapur)

Review of Emergency Preparedness Plans of NPPs

Successful demonstration of Emergency Preparedness and Response (EPR) plans is a mandatory requirement for issuing license for operation of NPPs. AERB ensures that necessary EPR plans are in place and they are successfully demonstrated before issuing regulatory consent for First Approach to Criticality. AERB evaluates all the elements of the EPR plans such as identification of emergency, classification, decision making, notification, communication, projected dose assessment and ensures the periodic revision of these plans.

In the year 2014, AERB issued Safety Guidelines on “Criteria for Planning, Preparedness and Response for Nuclear or Radiological Emergency” (AERB/NRF/SG/EP-5, 2014 (Rev. 1)) which is in line with IAEA safety guide GS-G-2 (2011). This safety guideline provides criteria for establishing an emergency preparedness and response plan to deal with nuclear and radiological emergency.

AERB has issued guidelines for preparation, review and approval of EPR plans to ensure harmonization of all EPR plans of NPPs. The AERB guidelines on EPR are in line with latest published IAEA safety documents on EPR (GSR part-7, GSG-2.1, GSG2 and GSR part-3).The EPR plans of NPPs are reviewed by the experts committees constituted by AERB and also by NPCIL with the mandate of ensuring harmonization of all EPR plans and incorporation of fresh guidelines on emergency preparedness (e.g. AERB/NRF/SG/EP-5) based on concepts of emergency action levels, generic criteria, operational criteria etc.

Review of revised AERB Safety Guidelines "Preparation of Off-Site Emergency Preparedness and Response Plans for Nuclear Emergency" (AERB/NRF/SG/EP-2)

The Safety Guidelines "Preparation of Off-Site Emergency Preparedness and Response Plans for Nuclear Emergency" (AERB/NRF/SG/EP-2, 1999) is under revision. This provides necessary requirements and guidance for establishment of off-site emergency preparedness and response plan for nuclear emergency in an effective, coordinated and integrated emergency response. The implementation of protective actions is based on generic criteria and operational criteria. This revised AERB Safety Guideline is in line with GSR-Part-7. AERB had taken up the revision of safety guidelines on "preparation of offsite emergency preparedness and response plan for nuclear emergency (AERB/SG/EP-2)" to incorporate the following:

a. Criteria for Emergency Planning, Preparedness and Response for Nuclear or Radiological Emergency AERB/NRF/SG/EP-5 (Rev. 1, 2014), which includes Generic Criteria and Operational Criteria (EAL, OIL and observables).

b. NDMA Guidelines and DM Act Requirements.

c. IAEA GSR Part-7 (2015) Preparedness and Response a Nuclear or Radiological Emergency.

d. Experience gained during IRRS Mission to India (2015).

The regulatory requirements with respect to off-site emergency declaration and responsibilities of site emergency director as a technical advisor to off-site emergency director are adequately addressed in this safety document. Also, regulatory requirements for licensees to test all emergency response functions over a determined period of time etc. have been provided in revised EP-2 (draft). Subsequent to completion of final version of the revised safety guidelines, AERB organized presentations and discussion on AERB/SG/EP-2, Rev.1, 2016) at all NPP sites to familiarization and obtain feedback from utilities.

Creation of On-Site Emergency Support Centre at NPPs

Based on the reviews undertaken on safety assessments of Indian NPPs, in light of the accident at Fukushima NPPs, AERB had mandated the requirement for establishing the On-Site Emergency Support Centre (OESC) at all NPP sites. AERB had constituted an Advisory Committee to develop the guidelines for establishing OESC at all NPP sites. AERB after a detailed review, accepted the generic guidelines for establishing OESC and had asked NPCIL to submit design basis report for the site specific OESC for all NPP sites in accordance with the accepted generic guidelines. The design of OESC has been finalized by the utility. AERB has reviewed and accepted this design and the implementation is in progress.

Activation of Nuclear and Radiological Emergency Monitoring Cell at AERB

The implementation of off-site emergency preparedness and response plan during actual emergency situation in public domain is the responsibility of District, State and National Authority and Department of Atomic Energy (DAE). As per the existing requirements, the information of any nuclear and radiological emergency situation in India is to be reported to these authorities, including AERB. In order to strengthen the monitoring of progress of emergencies and the review of actions taken by the involved agencies, a Nuclear and Radiological Emergency Monitoring Cell (NREMC) is established at AERB. The cell consists of experts who will activate the cell on short notice to assess the emergency situation and the actions performed by various agencies to handle the emergency. This newly established Nuclear and Radiological Emergency Monitoring Cell (NREMC) with the infrastructure of communication facilities, documents and protocols to obtain the information during the emergencies from concerned agencies and standard operating procedure (SOP) was activated during the off-site emergency exercises conducted at NPPs to review effectiveness of NREMC.

The NREMC was first activated on March 11, 2016 during actual plant emergency at Kakrapar (KAPS-1&2). It was activated as soon as the first information of the incident reached at AERB. NREMC operated in round the clock shift till the plant emergency was terminated on March 21, 2016. The cell monitored emergency situation and response actions taken and assessed radiological impact on-site and off-site and ensured there was no any radiological impact due to event at KAPS.

IRRS Peer Review of Emergency Preparedness and Response (EPR) and Follow-up Actions

As a part of the IAEA Integrated Regulatory Review Service (IRRS) Mission of AERB, which was carried out during March 17-27, 2015, the role of AERB with respect to EPR aspects were also reviewed.

IRRS review on EPR brought out few recommendations, suggestions and good practices. The recommendations were to review and revise the regulatory requirements with respect to off-site emergency declaration, responsibilities of site emergency director as a technical advisor to off-site emergency director and on development of internal emergency arrangements within AERB. AERB is in the process of revising Guidelines AERB/SG/EP-2 in which all the recommendations made by IRRS team have been adequately addressed. In addition AERB has prepared action plan to get prompt and accurate information on the emergency situation at the affected plant to perform its intended emergency response functions effectively. The suggestions such as implementation of Regulatory requirements as laid down in AERB/NRF/SG/EP-5, establishing seismically and environmentally qualified site emergency support centres at all sites, establishing regulatory requirements for licensees to test all emergency functional objectives over a determined period of time etc. are being complied with.

IRRS team observed AERB's system for tracking the status of and decisions related to recommendations and actions on EPR arising from reviews and exercises as good practice.

Participation in Emergency Exercises Conducted by IAEA

India is signatory under the IAEA Conventions on "Early Notification of a Nuclear Accidents" and Assistance in case of a Nuclear Accident or Radiological Emergency. Under these conventions, India has agreed to provide notification of any nuclear accident that occur within its jurisdiction that could affect other countries and any assistance can be provided in the case of a nuclear accident that occurs in another state that has ratified the treaty. The Crisis Management Group of Department of Atomic Energy (CMG-DAE) is the national contact point for India for these conventions. Periodic exercises are conducted by IAEA for training and preparedness of the involved agencies. These exercises are of three types, viz. ConvEx-1 covers communication & notification aspects, ConvEx-2 covers aspects related to requesting and / or providing assistance during emergencies, and ConvEx-3 cover all aspects of early notification & assistance convention. During the year 2015-2016, representative from AERB participated in the following three exercises.

- Emergency Exercise ConvEx-2b during August 25-27, 2015 to test the ability of national competent authorities to complete the appropriate reporting forms and provide the assistance to the requesting state.

- Emergency Exercise ConvEx-2c on December 15, 2015 to allow member states to test arrangements for a transnational radiological emergency.

- Emergency Exercise ConvEx-2a on February 17, 2016 to test the ability of national competent authorities to complete the appropriate reporting forms.

Chapter 7 Safety Documents

One of the mandates of AERB as given in its constitution is to develop Safety Codes, Guides and Standards for different phases and for different types of plants, keeping in view the international recommendations and local requirements. Accordingly, AERB has put in place a well-established process and mechanism for development of regulatory documents as specified in AERB safety guide AERB/NRF/SG/G-6 (Rev. 1). The framework for document development in AERB involves a multi-tier system of committees of experts. The experts are drawn from the National R&D Centres, Industries, Academic Institutes and Government Organisations, apart from retired specialists having experience in the related fields, available in the public domain.

The dynamic process of document development takes account of,

- Outcome of discussions / safety reviews.
- Requirements felt during consenting or enforcement.
- New regulatory and technological developments relevant to AERB.
- International practices.
- Specific aspects of recommended/ accepted practices.
- Experience/ feedback from Nuclear and Radiation facilities.

Regulatory safety documents issued by AERB are classified in the following decreasing order of hierarchy:

(a) Safety codes
(b) Safety standards
(c) Safety guidelines
(d) Safety guides
(e) Safety manuals
(f) Technical documents

The requirements covered in safety codes and safety standards are mandatory in nature. The safety guide is a safety document containing detailed guidance and methodologies that are acceptable to AERB to implement the specific parts of a safety code/safety standard. Safety guides are recommendatory in nature.

AERB involves experts, utility and interested parties in the development of the regulations and guides through whom the comments and feedback are received throughout the development stage. Technological advances, international guidelines, research and development work, relevant operational lessons learned and institutional knowledge are considered as appropriate in development/revision of the regulations and safety documents. Feedback from nuclear and radiation facilities is also considered while preparation of new document or for revision of an existing document.

AERB has issued regulations and safety documents which provide adequate coverage commensurate with the radiation risks associated with the facilities and activities, in accordance with a graded approach. Till date, AERB has published 156 regulatory safety documents. The progress on regulatory safety documents during the year 2015-16 is given below:

7.1 NEW/REVISED SAFETY DOCUMENTS PUBLISHED IN THE YEAR 2015-16

1. AERB revised Safety Code titled 'Radiation Processing Facilities' [AERB/RF-RPF/SC-1(Rev.-1)]

Radiation processing facilities that utilize ionizing radiations are used for a variety of beneficial applications such as sterilization of medical products, processing of food and allied products, mutation breeding, cross linking and other industrial processing. These facilities include Gamma Radiation Processing Facility (GRAPF) and Industrial Accelerator Radiation Processing Facilities (IARPF). This safety code consolidates all the regulatory requirements relevant to radiation processing facilities utilizing sources of ionizing radiation including radioactive sources and radiation generating equipment (GRAPF & IARPF) in a single document. It supersedes the earlier safety code 'Operation and Maintenance of Land Based Stationary Gamma Irradiator' (AERB/SC/IRRAD; 1993).

2. AERB revised Safety Code titled 'Safe Transport of Radioactive Material' [AERB/NRF-TS/SC-1 (Rev.1)]

The safety code on 'Transport of Radioactive Material, AERB/SC/TR-1; 1986 issued by AERB specifies requirements for the design and test of special form of radioactive material and different types of packages which may be deployed for the transport, control measures to be implemented during transport including the limits on the levels of radioactive contamination, radiation level and temperature at the external surface of a package, marking and labeling. This revised safety code, supersedes the earlier code AERB/SC/TR-1 (1986), and additionally provides requirements on design and test requirements for low dispersible radioactive material, Type C packages, fissile-excepted material and management system in line with the applicable international standards.

3. AERB revised Safety Code titled 'Industrial Radiography' [AERB/RF-IR/SC-1 (Rev.1)]

The safety code on 'Industrial Radiography', [AERB/RF-IR/SC-1 (Rev.1)], specifies requirements for industrial radiography institutions, covering the entire spectrum of operations ranging from setting up of a industrial radiography facility to its ultimate decommissioning, including procedures to be followed during radiological emergency situations. The safety code also stipulates the requirements for radiography equipment and sources and personnel requirements and responsibilities.

The revision has been carried out in view of the advancement in radiography equipment, changes in basic educational qualification for certified radiographer, regulatory requirements for ensuring security of radiography sources at radiation facilities and during their transport, and in the light of experience and feedback from users. This revised safety code, supersedes the earlier code AERB/SC/IR-1 (2001) and consolidates all the regulatory requirements relevant to industrial radiography.

4. AERB revised Safety Code titled 'Radiation Safety in Manufacture, Supply and Use of Medical Diagnostic X-Ray Equipment' [AERB/RF-MED/SC-3 (Rev. 2)]

The Medical X-ray diagnostic radiology practice is the most widespread utilization of ionizing radiation in the public domain. The safety code stipulates radiological safety requirements for indigenous manufacturers of X-ray equipment/X-ray tubes, suppliers of imported/indigenous medical diagnostic X-ray equipment/X-ray tubes and facilities using these equipment in order to ensure that radiation workers and members of public are not exposed to radiation in excess of dose limits prescribed by the Competent Authority, reduce radiation exposures below these limits to levels As Low As Reasonably Achievable (ALARA) and ensure that radiation exposures received by patients undergoing diagnosis are suitably optimized.

The revised safety code supersedes the earlier safety code titled 'Medical Diagnostic X-ray Equipment and Installations' (AERB/SC/MED-2) which was issued in December 1986, and subsequently revised in 2001.The current version also takes into account the provisions of the Atomic Energy (Radiation Protection) Rules, 2004 and the interim amendment to the safety code issued by AERB in November 2012.

5. AERB Safety Guidelines titled 'Nucleonic Gauges and Well Logging Applications' (AERB/RF-IGD/SG-1)

A large number of nucleonic gauges and well-logging devices are in use in India. The well logging devices incorporate relatively high activity neutron sources in addition to gamma sources. The nucleonic gauging devices, on the other hand, mostly have low activity sources. This safety guideline specifies regulatory requirements as well as methodologies for compliance by end users and suppliers of nucleonic gauges and well-logging sources. It provides requirements for handling of the devices viz. manufacturing, supply, procurement, receipt from the supplier, installation, operation and decommissioning, and disposal of the disused sources. It also provides requirements of safety infrastructure from radiation safety and security considerations, and personnel and their responsibilities.

6. AERB Safety Guidelines titled 'Gamma Irradiation Chambers'(AERB/RF-RPF/SG-2)

This Safety Guidelines specifies and elaborates the regulatory requirements for compliance by manufacturers/users of Self-Contained Dry Source Storage Gamma Irradiator (Category–I), also known as Gamma Irradiation Chamber (GIC). It covers consenting stages viz.design, site and layout for installation, commissioning, operation, decommissioning and disposal of disused sources. It also specifies the design safety aspects of various critical components and sub-assemblies of the source container of GIC including the quality assurance programme during its design, fabrication and commissioning, and stipulates requirements of personnel and their responsibilities, safety infrastructure from radiation safety and security considerations.

7. AERB Safety Guidelines titled 'Safety in Design and Application of Laser' (AERB/ SG/ IS-7)

Light Amplification by Stimulated Emission of

Radiation (LASER) is utilized in units of DAE for industrial and R&D purposes and has unique applications in the nuclear fuel cycle. The LASER can cause irreparable damage to vital parts of the eye, such as retina, cornea and eye lens and other associated electrical, fire and chemical hazards depending on their use in various modes of operation, type of beams in the ultraviolet to far infrared regions of the electromagnetic spectrum, and even extending to the X-ray region. The safety guidelines provides guidance on the organization's policy and requirement of control measures appropriate to the hazard potential of all types of LASER in order to prevent any harm occurring, or any person from being exposed to an unacceptable level of risk.

8. AERB Safety Guide titled 'Plant Commissioning/ Re-Commissioning Dosimetry for Food and Allied Products in Gamma Radiation Processing Facilities-Category II & IV' (AERB/RF-RPF/SG-1)

The Gamma Radiation Processing Facilities (GRAPF) are required to carry out plant commissioning/re-commissioning dosimetry to determine absorbed dose profile, statistical variation in absorbed dose in food and allied products and setting of operational parameters. This safety guide provides guidance for developing the standard operating procedures to be followed for conducting the plant commissioning/re-commissioningdosimetry based on the design of the facility, and standard format for preparing the dosimetry report for submission.

9. AERB Safety Guide titled 'Radioisotope Handling Facilities' (AERB/RF-RS/SG-2)

This safety guide provides regulatory guidance with respect to radiological safety, waste management and transportation aspects relevant to siting, design, construction, operation and decommissioning of Type III radioactive facilities, such as facilities for commercial production of radioisotopes and radio-pharmaceuticals for medical, industrial and research applications.

10. AERB Safety Guide titled 'Regulatory Review of Level-1 Probabilistic Safety Assessment (PSA) for Nuclear Power Plants and Research Reactors' (AERB/NPP&RR/SG/G-10)

A Probabilistic Safety Assessment (PSA) of a nuclear power plant (NPP) provides a comprehensive and structured approach for identifying failure scenarios and deriving numerical estimates of the risks to workers and members of the public.

It provides a systematic approach to determine whether safety systems are adequate, the plant design isbalanced and the defense in depth requirement have been realized. This safety guide outlines standard review methodology for Level-1 PSA, which identifies the sequences of events that can lead to core damage, estimates core damage frequency and provides insights into the strengths and weaknesses of the safety systems and procedures provided to prevent core damage. It also provides consistent technical approaches on aspects of PSA and guidance for preparation of the review report.

7.2 SAFETY DOCUMENTS TRANSLATED AND PUBLISHED IN HINDI

Following regulatory safety documents were translated and published in Hindi language during the year.

7.3 SAFETY DOCUMENTS UNDER DEVELOPMENT

The following regulatory safety documents are under development/review:

1. AERB Safety Guide titled 'In-service Inspection of Nuclear Power Plants' (AERB/NPP/SG/O-2) is under revision.

1.	Hydrogeological Aspects of Siting of Nuclear Power Plants	AERB/SG/S-4, 2000
2.	Security of Radioactive Sources in Radiation Facilities	AERB/RF-RS/SG-1, 2011
3.	Radiation Therapy Sources, Equipment and Installations	AERB/RF-MED/SC-1 (Rev. 1), 2011
4.	Atmospheric Dispersion and Modeling	AERB/NF/SG/S-1, 2008

2. AERB Safety Guide titled 'Periodic Safety Review of Nuclear Power Plants' [AERB/SG/O-12 (Rev.1)].

3. AERB Safety Manual titled 'Format for Report on Collective Dose Expenditure and Budgeting for Current Year in Nuclear Power Plants' (AERB/NPP/SM/O-3).

4. AERB Safety Guide titled 'Quality Assurance in Nuclear Power Plants' [AERB/SG/QA (Rev 1)].

5. AERB Safety Guide titled 'Remediation of Radioactively Contaminated Environment' (AERB/NRF/SG/RW-9).

6. AERB Safety Guide titled 'Monitoring and Assessment of Radiation Dose Due to Internal Uptake of Radionuclides in Nuclear and Radiation Facilities' (AERB/NRF/SG/RP-1).

7. AERB Safety Guidelines titled 'Preparation of Off-site Emergency Preparedness Plans for Nuclear Facilities' [AERB/SG/EP-2 (Rev.1)].

8. AERB Safety Guidelines titled 'Commissioning, Operation and Maintenance of Nuclear Fuel Reprocessing Facilities' (AERB/BE-FCF/SG-2).

9. AERB Safety Guide titled 'The Safe Transport of Radioactive Material' [AERB /NRF-TS/SG-1 (Rev.1)].

10. AERB Safety Guide titled 'Standard Format and Contents of Safety Analysis Report for Nuclear Power Plants' (AERB/NPP /SG/G-9).

7.4 REVIEW OF IAEA DRAFT DOCUMENTS

AERB reviews draft IAEA documents as well as draft document profiles presentation (DPP) and provides comments. The following IAEA Safety Standards were reviewed during the period:

7.4.1 IAEA Draft Documents

(i) Safety of Nuclear Fuel Reprocessing Facilities (DS 360)

(ii) Safety of Nuclear Fuel Cycle Research and Development Facilities (DS 381)

(iii) Radiation Protection and Safety in Medical Uses of Ionizing Radiation (DS 399)

(iv) A General Framework for Prospective Radiological Environmental Impact Assessment and Protection of the Public (DS 427)

(v) Regulatory Control of Radioactive Discharges to the Environment (DS 442)

(vi) Decommissioning of Medical, Industrial and Research Facilities (DS 403)

(vii) Predisposal Management of Radioactive Waste from the Use of Radioactive Materials in Medicine, Industry, Agriculture, Research and Education (DS 454)

(viii) Establishing the Infrastructure for Radiation Safety (DS 455)

(ix) Safety Requirements titled 'Leadership and Management for Safety' (DS 456)

(x) Communication and Consultation with Interested Parties by the Regulatory Body (DS 460)

(xi) Organization, Management and Staffing of a Regulatory Body for Safety (DS 472)

(xii) Functions and Processes of the Regulatory Body for Safety (DS 473)

(xiii) Safety Requirements titled 'Safety of Research Reactors' (DS 476)

(xiv) Safety of Nuclear Fuel Cycle Facilities (DS 478)

(xv) Severe Accident Management Programmes for Nuclear Power Plants (DS 483)

(xvi) Ageing Management and development of a Programme for Long Term Operation of Nuclear Power Plants (DS 485)

(xvii) Safety Guide on 'Protection against Internal Hazards in the Design of Nuclear Power Plants', Revision and combination of NS-G-1.7 and NS-G-1.11 (DS 494)

(xviii) Issues for taking up revision of 'The IAEA Regulations for the Safe Transport of Radioactive Material (2012 Edition)' (SSR-6)

(xix) Issues for taking up revision of 'Advisory material for the IAEA Regulations for the Safe Transport of Radioactive Material (2012 Edition)' (SSG-26)

(xx) Developing a National Framework for Managing the Response to Nuclear Security Events (NST004)

(xxi) Regulations and Associated Administrative Measures for Nuclear Security (NST 002)

(xxii) Building Capacity for Nuclear Security (NST 009)

(xxiii) Sustaining a Nuclear Security Regime (NST 020)

(xxiv) Physical Protection of Nuclear Material and Nuclear Facilities Safety of Nuclear Fuel Reprocessing Facilities (NST 23)

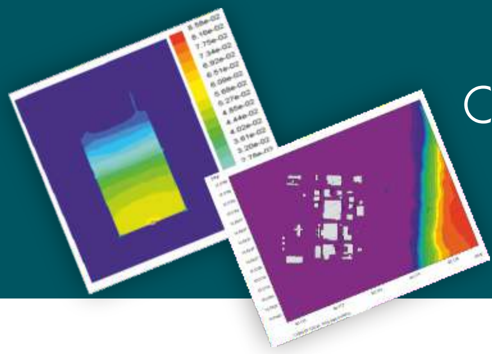
7.4.2 IAEA Draft Document Preparation Profile (DPPs)

The following IAEA draft Safety Standards and Document Preparation Profiles (DPP) were reviewed during the period for sending the national comments to IAEA.

i. Format and Content of the Safety Analysis Report for Nuclear Power Plants (DPP DS 449)

ii. The Structure and Information to be Included in a Package Design Safety Report (PDSR) for the Transport of Radioactive Material (DPP DS 493)

iii. Safety Requirements on 'Regulations for Safe Transport of Radioactive Material, Revision of SSR-6 (DPP 495)



Chapter 8

Safety Analysis And Research

Safety Research and Studies

AERB recognizes the importance of safety analysis and research in support of its regulatory work as it helps in obtaining deeper insights into the issues concerning nuclear and radiation safety to arrive at scientifically sound regulatory decisions. Safety analysis activities are carried out by Nuclear Safety Analysis and Research Group of AERB that includes Nuclear Safety Analysis Division (NSAD) and Safety Research Institute (SRI) (established by AERB at Kalpakkam, Tamil Nadu). Further, domain specific research is also being carried out in other divisions like Siting & Structural Engineering Division (SSED) and Industrial Plants Safety Division (IPSD).

AERB continued its independent verification of selected safety analysis to support the regulatory decisions. Several important developmental studies were taken up and completed during this year. A state-of-the-art Compartment Fire Test Facility (CFTF) has been established at AERB's SRI, Kalpakkam, for carrying out experimental studies relating to enclosure fires. AERB also promotes and funds radiation safety research and industrial safety research as part of its programme and provides financial assistance to universities, research institutions and professional associations for holding symposia and conferences on the subjects of interest to AERB. The highlights of safety analysis and R&D activities are presented below:

8.1 SEVERE ACCIDENT (SA) STUDIES

8.1.1. Development and Application of a New Methodology to Analyze ESBO in 540 MWe PHWR using RELAP5

The objective of the activity was to develop a new methodology to analyse severe accident in PHWRs. Severe accident analysis SCDAP/RELAP5 code has been developed primarily for vertical reactors such as PWR, BWR etc. Direct application of the code for entire phase of severe accident for horizontal reactors such as PHWR may not be appropriate. To overcome these modeling issues specific to PHWR, such as Pressure Tube-Calandria Tube (PT-CT) contact time for different channels, channel slumping and core disassembly, an alternate modeling strategy has been developed and applied for simulating ESBO in 540 Mwe PHWR. Hydrogen generation is also estimated in this study.

SBO scenario involves failure of both Class-IV and Class-III power supplies. During SBO, primary heat transport (PHT) system forced circulation will also be lost. Furthermore, with absence of heat removal from secondary side the fuel temperature starts rising, which in turn causes a rise in PT temperature leading to ballooning of PT resulting in PT-CT contact. In the absence of moderator circulation system, the moderator gets heated up and eventually boils leading to the rupture of over pressure rupture device (OPRD). Mechanical properties of the channel material deteriorate rapidly with temperature resulting in sagging of channels under the weight of the fuel bundle; as a result the channel disassembles, and relocates on top of the supporting submerged channels. Once the total debris mass exceeds the load bearing capacity of the supporting channels, the supporting channel along with the debris, collapse and relocates to the lower channels. This process continues till all the moderator is evaporated, leading to disassembly of all the channels, which eventually form corium at the bottom of the calandria. Hence, the new methodology developed was useful in getting insights on various phenomenon that may occur during a severe accident scenario in a PHWR configuration.

8.1.2. Effectiveness of Mitigatory Actions for LOCA Initiated Severe Accident in 540 Mwe PHWR

In case of severe accidents, despite the safety features, procedural action should be in place to mitigate the accident progression. The procedures for the preventive domain (EOPs) and guidelines for the mitigatory domain (SAMG) need to be developed to prevent the escalation of an event into a severe accident. Since in the mitigatory domain, uncertainties may exist both in the plant status and in the outcome of action, analysis to investigate the effectiveness of severe accident management provisions need to be performed. As a part of independent regulatory assessment, the effectiveness of SAMG action of water injection to calandria vessel is assessed for severe accident initiated by LOCA for 540 MWe PHWR using system thermal hydraulics code SCDAP/RELAP5/Mod3.4.

LOCA coincident with Loss of ECCS results in rise in PT temperature. Subsequently PT sags and touches CT leading to enhanced heat transfer to moderator. In the absence of moderator circulation system, the moderator pressure rises leading to opening of over pressure rupture devices (OPRDs) and moderator boil off starts. To mitigate rising temperature of pressure tube (PT), calandria tube (CT) and fuel, SAMG prescribes direct addition of water into the calandria vessel as soon as calandria level reaches to low level alarm set point. It was concluded that, SAMG action was successful in not only effective removal of decay heat, but also the stored heat, resulting in decrease in clad temperature.

8.2 HYDROGEN DISTRIBUTION AND CONTAINMENT SAFETY STUDIES

8.2.1 Containment Filtered Venting System Performance (CFVS) Analysis with integrated Model using RELAP5

The objective of the study was to assess the performance of the containment filtered venting system (CFVS) using an integrated model. A model was developed to integrate the primary coolant system, containment and the venting system. Analysis were carried out to investigate the effect of inlet fluid temperature, air-steam mixture and venturi-submergenceon the performance of the proposed containment filtered venting system.The integrated modelling was used to investigate the performance of the venting system under severe accidents LOCA without ECCS and SBO with mitigating action of water injection into the upper plenum at a rate of 5 kg/s after 4 hours of the SBO initiation. Credit of suppression pool inventory was considered in both the cases analysed. Maximum drywell pressure was estimated to be around 1.7 bar after the initiation of LOCA. Adequacy of the injection rate was assessed. In both the initiating events analysed, it was observed that the venting system was able to limit the containment pressure.

8.2.2 Numerical Studies on Hydrogen Mitigation in Steam Environment

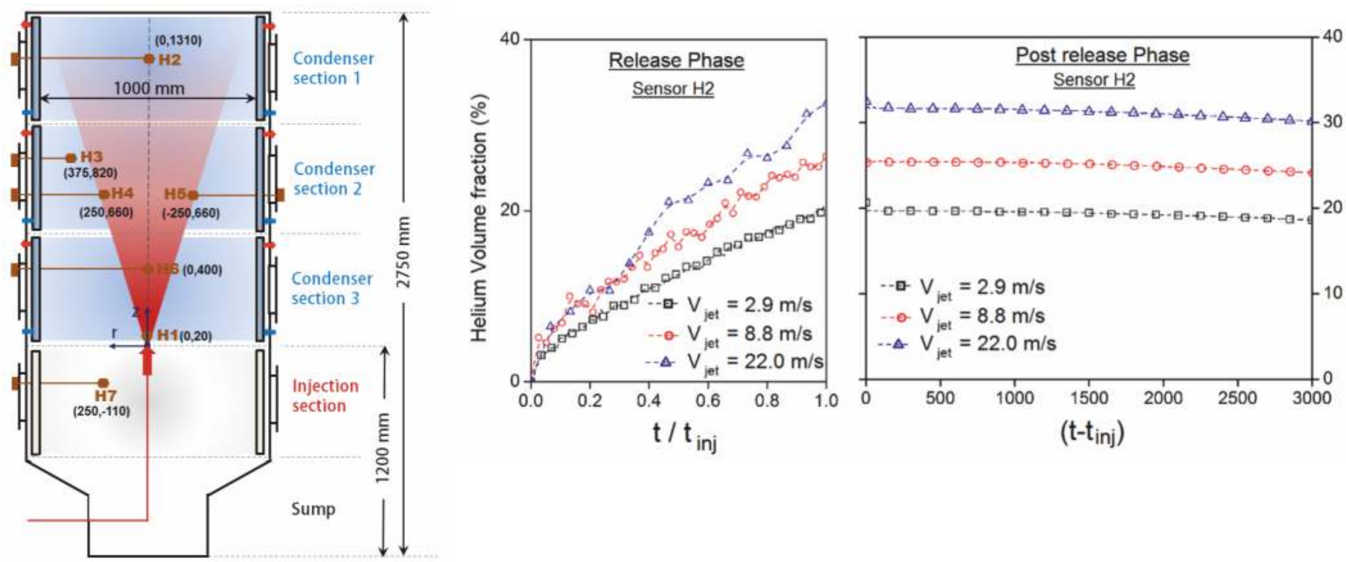
After Fukushima accidents, nuclear reactors are being fitted with passive autocatalytic recombiners (PAR). These recombiners have a vertical stack of catalyst coated plates on which spontaneous exothermic surface reactions take place and hydrogen is converted into water. An important safety requirement is to ensure that the catalyst plate does not cause sustained ignition in the gas mixture. For this, the catalyst surface temperature has to be determined. The numerical studies to determine the catalyst surface temperature and gas concentration profiles during hydrogen removal were extended to include the presence of steam in the incoming mixture. A 12-step reaction model for hydrogen-steam-air gas mixture was used in the study. Numerical studies indicated that the rate of reaction decreases with increase in steam concentration. As a result, more surface area is required to enable complete reaction of gas mixture.

8.2.3 Hydrogen Mitigation Facility (HYMIF)

An experimental facility "Hydrogen Mitigation Facility" is being setup within the Engineering hall of the Safety Research Institute (SRI) of AERB at Kalpakkam to investigate hydrogen recombination using passive auto-catalytic recombiners, igniters etc. The performance and safety aspects of hydrogen recombination devices in small scale setups will be brought out. Safety clearance for the Phase-1 experiments has been obtained from IGCAR Safety Committee (Other Facilities). Main components of the bench setups have been fabricated.

8.2.4 AERB IITM Hydrogen Mixing Studies (AIHMS) Facility

The AERB IITM Hydrogen Mixing Studies (AIHMS) Facility has been erected in the IIT Madras premises under the patronage of AERB-CSRP. The facility consists of the following components: a test enclosure, steam generator, helium gas and air supply units, constant temperature water bath, process control unit, data acquisition system and an overhead manually operated crane. The layout and components of the test facility are schematically shown in Figure 8.1. Experimental studies on the release and distribution of isothermal jet of helium in the test chamber and the effect of wall temperature on the gas stratification behavior within the enclosure have been performed. Numerical studies using commercial CFD codes are in progress to validate the models using the experimental data for



(a) (b)

Fig. 8.1: (a) AIHMS test chamber with location of helium sensors, (b) experimental results for helium concentration at sensor location H2

8.3 THERMAL HYDRAULICS SAFETY STUDIES

8.3.1 Assessment of Dew Point Calculations in Annular Gas Monitoring System for Postulated Leak in Primary Heat Transport System

The thermal hydraulic analysis was carried out for estimation of effect of inlet dew point and postulated leak from Primary Heat Transport (PHT) system on outlet dew point for annulus gas monitoring system (AGMS). The postulated cumulative leak from PHT was calculated. The Psychometric details were studied and dew point calculations were performed. The flashing of leaked coolant from PHT system was also modeled. Detail calculations were performed based on fundamental principles due to absence of data for CO_2 – Water vapour binary mixtures. The outlet dew point was estimated for different values of inlet dew point and PHT leak. It was noted that for a fixed inlet dew point, as the leak increases, the rise in outlet dew point decreases. It was also noted that for smaller leaks, the outlet dew point is sensitive to inlet dew point variations. For a fixed leak, as the inlet dew point increases, the rise in outlet dew point increases.

The variation of difference between outlet and inlet dew point for different PHT leak with different inlet dew points was also analysed. It was noted that for fixed inlet dew point, as leak increases, the difference between outlet and inlet dew point increases but at slower rate for higher leaks as compared to lower leaks. For a fixed higher leak, the difference between outlet and inlet dew point decreases almost linearly with inlet dew point. For a fixed leak in lower range, the difference between outlet and inlet dew point changes significantly in the lower inlet dew point range.

8.3.2 Performance Evaluation of PDHR system of 700 MWe PHWR at various power levels

The objective of the study was to evaluate the performance of Passive Decay Heat Removal System (PDHRS) at various power levels. PDHRS are being provided in all the upcoming 700MWe PHWRs in India as a First of a Kind (FOAK) system to handle prolonged Station Black-Out (SBO) conditions. Parametric studies were carried out to identify the influence of various parameters such as the PDHRS valve-in time, reactor power level etc. on the transient evolution. The transients' analysis was continued for a period of 8 hours. It was found that under different reactor power levels (100%, 75% and 50% FP) as well as PDHRS valve-in times (0, 15 and 30 min), the system is capable of carrying away the decay heat from the core and transfer the same to the ambient. Also it is seen that after eight hours of initiation of SBO the level in PDHR Stank comes down to around 1.9m for 100% full power case, which suggests that the PDHRS can sustain SBO for more than eight hours. It was concluded that PDHRS is capable of performing its intended functions effectively at all powers. The study was used as a supporting analysis during the review of the PDHRS by AERB.

8.3.3 Mathematical Model for Containment Spray

An analysis is carried out using the existing mathematical model on the efficacy of containment spray system in a 700 MWe PHWR. Two parametric studies were carried out. In the first case, the mean diameter of the spray is varied in steps starting from 500µm to 2000µm at constant flow rate. In the second case, the volumetric flow rate of the injected spray is varied in the range of 50-300m^3/hr, keeping the droplet diameter constant at 500µm. It was found that the peak pressure and temperature with the actuation of spray system are 1.08kg/cm^2 (g) and 106.5oC respectively. It was observed that time integrated over pressure and containment ambient temperature reduce at a faster rate with decrease in droplet and with increase in spray mass flow rate.

8.3.4 Effect of ECCS injection on containment peak pressure in KGS 1&2 during Large Break Loss of Coolant Accident (LB-LOCA)

Maximum pressure inside the containment of any reactor building after an accident like LOCA (Loss of Coolant Accident) will influence the release of fission products. Hence determination of containment peak pressure during such transients is important. Thermal hydraulic analysis of reactor containment has been carried out to estimate containment peak pressure during LB-LOCA in KGS 1&2. To obtain the blowdown discharge into containment, complete modelling of primary and secondary system of plant was carried out using RELAP5. Containment modelling with its internals was carried out using ASTEC. Large break LOCA is considered in the inlet header of primary heat transport system with its discharge into the fuelling machine-vault north compartment of containment. Two cases were studied i.e. with and without ECCS injection into primary. From the analysis the peak containment pressure in KGS 1&2 for both the cases; with and without ECCS, were estimated. Marginal reduction in peak pressure was observed in the case where ECCS is credited due to extra cooling provided by ECCS injection resulting in reduction in steam discharge into the containment. Containment peak pressure estimated using ASTEC was found to be below LOCA design pressure for 220 MWe PHWR.

8.4 EXPERIMENTAL STUDIES

8.4.1 Performance Comparison of He-4 Scintillation Detector with He-3 and BF3 Based Detectors for Application of Pu Assay

He-3 and BF3 thermal neutron detectors are widely used for neutron detection, spectroscopy, assay of fissile materials and security applications etc. They detect neutrons using the 3He (n, p) 3 Hand 10B (n, α) 7Li capture reactions respectively. Active neutron interrogation technique using 3He or Bf3 detectors need both the source and induced fission (in the sample) neutrons to be moderated to maximize the fission reaction rate and detection efficiency with minimum flux loss. Among these, 3He is more sensitive. As 3He has encountered huge problems in matching the supply and the demand, development of alternative neutron detection technologies are under progress. One of them is high pressure 4He gas filled scintillation detectors which uses elastic scattering of 4He nucleus for the neutron detection. With this context, a theoretical study using Monte Carlo based code is carried out to compare the response of 3He (4 atm, 100% pure) and Bf3 detectors (0.52 atm, 90% of 10B enrichment) with moderator and high pressure (150 bar, 100% pure) 4He detectors without moderator. The results are plotted in the Figure 8.2. using Monte Carlo simulations it is found that 4He fast neutron detectors (averaged internal efficiency of 3%) are 6 times less sensitive than 3He and 1.5 times less than BF3 detectors (considered internal efficiency of 100%).

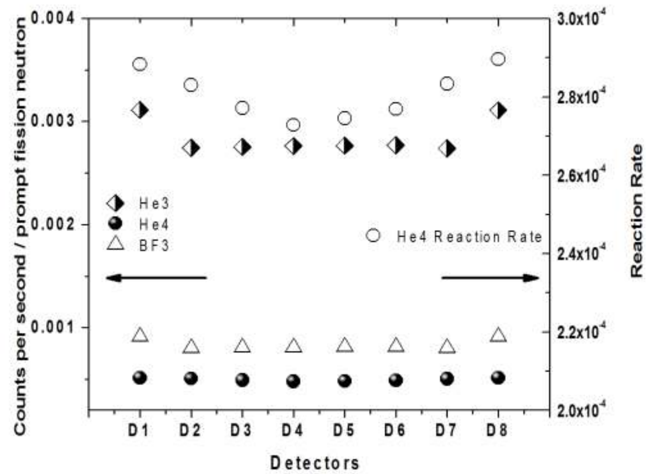


Fig. 8.2: Comparison of the response of the ^{3}He, BF_3 and ^{4}He detectors per prompt fission neutron of Pu

8.4.2 Estimation of Compton Scattered Contribution of Higher Energies in High Purity Germanium (HPGe) detector using Monte Carlo Simulations

High Purity Germanium (HPGe) gamma radiation spectrometers are used for the environmental radioactivity analysis of complex radio nuclides emitting multiple gamma energies. The accuracy of the activity analysis using this detector depends on the efficiency of the detector in the counting geometry. Though the efficiency as a function of energy is determined with the most care for a given source to detector geometry, the contribution due to Compton scattering of higher gamma energies to lower energies cannot be avoided completely in experimental measurements and this in turn results in uncertainty in activity analysis. Though the net photo peak area arrived after using the de-convolution techniques is powerful enough to take care of Compton contributions, it is not followed everywhere. In view of this, the study has been carried out to quantify contribution due to Compton scattering of higher energies to lower energies for Eu-152 gamma source using Monte Carlo simulations. The percentage contribution due to Compton scattering of higher energies to the lower energies is given in Figure 8.3. It was observed that, for most of the lower energies having higher probability of emission, the individual contribution from higher energies are less than 5%, whereas for lower energies with very less probability, the percentage contribution from higher energies ranges from 5.3% to 16.2%. For activity measurements of complex radioactive nuclides emitting multiple gamma energies, the present study recommends to consider the effect of contribution due to Compton scattering of higher energies, if they have higher probability of emission.

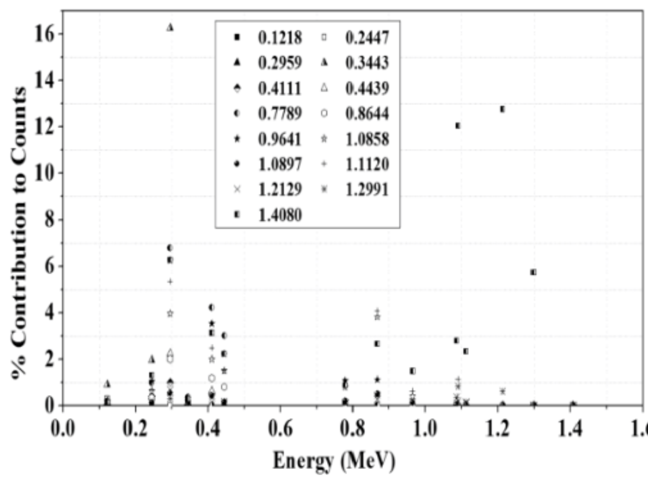


Fig. 8.3: Percentage contribution due to Compton scattering in the other energy regions

8.5 INTERNATIONAL COLLABORATIVE SAFETY ANALYSIS EXERCISES

8.5.1 Analysis of OECD/NEA HYMERES PROJECT (Hydrogen Mitigation Experiments for Reactor Safety)

AERB is participating in OECD/HYMERES project. The objective of the HYMERES project is to investigate safety relevant issues for the analysis and mitigation of a severe accident leading to release of hydrogen into reactor containment. The project involves a series of experiments being conducted in the PANDA (PSI, Switzerland) and the Mitigation and Stratification (MISTRA) (CEA, France) facilities.

CFD Simulation of PANDA test HP1_6_2 for Blind Benchmark Exercise

A blind benchmark exercise for CFD calculations was floatedby Paul Scherrer Institute (PSI, operating organization for PANDA) based on one of the PANDA tests – HP1_6_2. This test involves interaction of a vertical steam jet with an obstruction and its influence on the distribution of stratified helium layer in the PANDA vessel.Two separate models – 'Common Model' (Specified by the organizing institute) and 'Best Estimate Model' (selected by the participant) were used for the simulations at AERB. Subsequent to the release of experimental data by PSA, blind calculation results were compared with the experimental data as presented in Figure 8.4. Both the models successfully captured the interaction of jet with the obstruction and subsequent erosion and distribution of helium in the vessels.

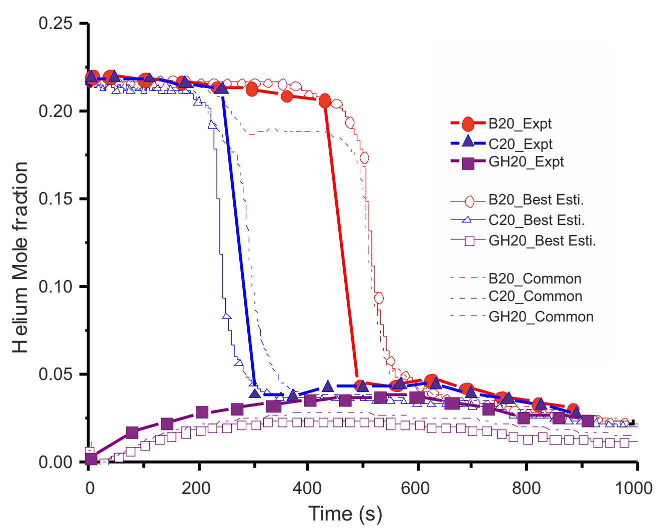


Fig.8.4 Variation of He mole fraction at different elevations

CFD Simulation of HM2 and HM3 Series Tests of MISTRA facility under HYMERSE project

HM2 and HM3 tests of MISTRA facility are dedicated for studying the thermal effect of passive autocatalytic recombiners (PARs) in containment. HM2 series of experiments focuses on effect of single heater on mobilization of helium layer whereas in HM3 series, interaction between two heaters and effects on dispersion of rich helium layer is studied. The test

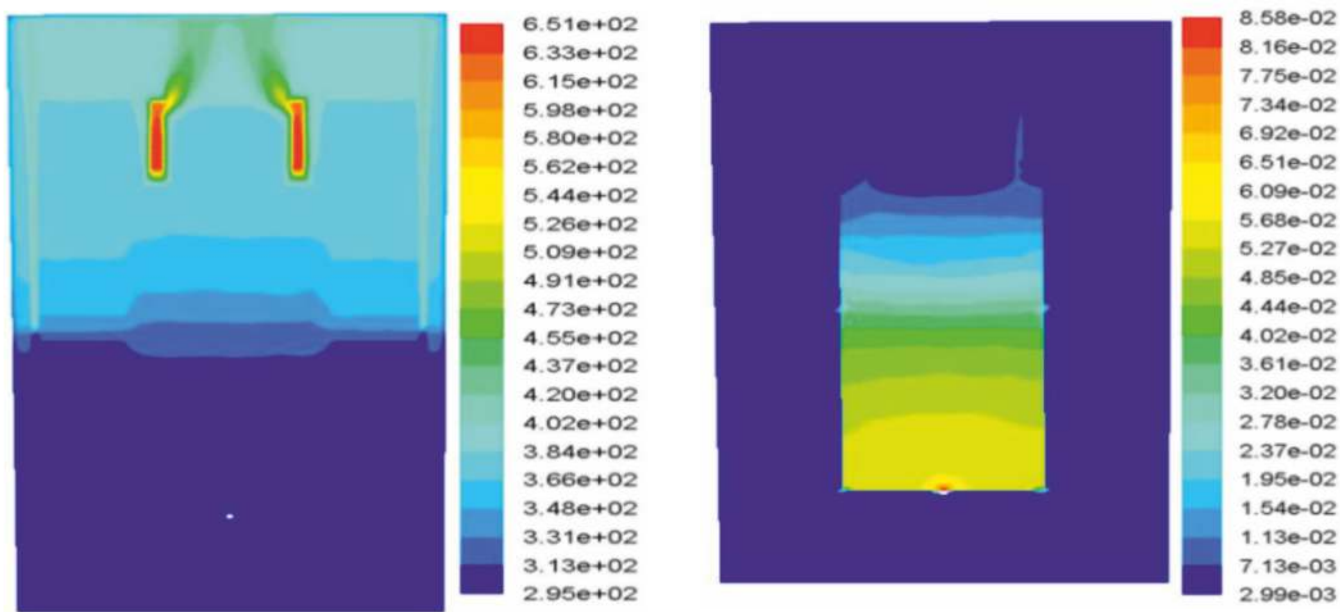


Figure 8.5b

Fig 8.5a: Temperature and Helium Contours at 32000 s (HM3-1)

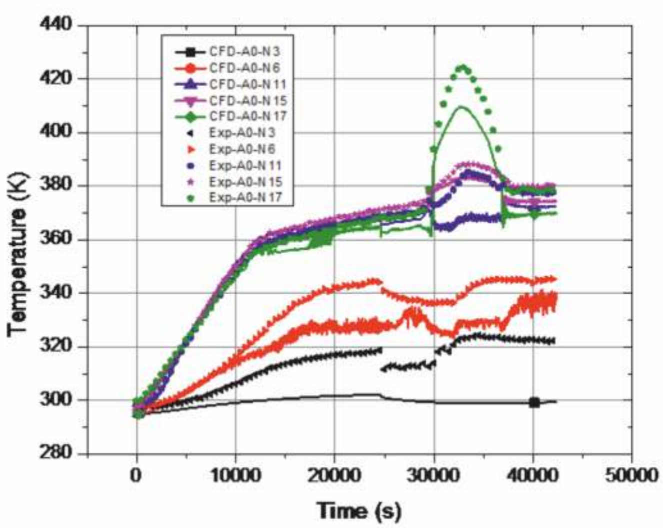


Fig 8.5b: Temperature at Monitoring Locations (HM3-1)

sequence of HM2 and HM3 series is divided into various phases and CFD simulation is carried out for pre heating phase, injection phase, PAR operation and relaxation phase. Simulations were carried out with 180° sector model for HM2 series whereas full 360° domain has been modelled for HM3 series. Heat losses are considered from the top and outer surface of facility and thermal inertia of the structure walls is also considered. Computationally efficient heater model developed has been used for the third and fourth phase (PAR operation) of the simulation, which results in faster computation.

The temperature and helium contour at the end of third phase (end of helium injection) for HM3-1 test is presented in Figure 8.5a. No interaction between heaters is observed in the simulation and same has been confirmed by the experimental data. Figure 8.5b presents the comparison of temperature predicted by CFD simulation and experimental data at different monitoring locations for the HM3-1 test. It was concluded that in general, CFD simulations captured the phenomena in all phases of the experiment and the predictions are in reasonable agreement with the experimental data.

8.6 PROBABILISTIC SAFETY ANALYSIS

8.6.1 Reliability Assessment of Containment Filtered Venting System (CFVS)

The containment filtered venting system is designed for relieving the pressure in containment and also to mitigate the consequence of hydrogen detonation. Being one of the important systems in severe accident management, the objective of analysis was to assess the system reliability for various configurations of components. The reliability analysis of CFVS was performed using RISK SPECTRUM code. The CFVS consists of valves, scrubber tank etc. The system was modelled using fault tree approach. Six different cases were modelled for various combinations. The CFVS unavailability was estimated for various combinations and success criteria.

8.6.2 Human Error Probability Estimation

A new methodology was proposed to estimate Human Error Probability (HEP) from simulator data for operator action under accident condition & uncertainty analysis in plant system response and operator error in diagnosis and execution of task have significant impact on Nuclear Power Plant (NPP) safety. These human errors are classified as mistakes (rule base and knowledge based errors), slip (skill based) and lapses (skill based). Depending on the time of occurrence, human errors have been categorized as i) Category 'A' (Pre-Initiators): actions during routine maintenance and testing where in errors can cause equipment malfunction ii) Category 'B' (Initiators): actions contributing to initiating events or plant transients iii) Category 'C' (Post-Initiators): actions involved in operator response to an accident. There have been accidents in NPPs because of human error in an operator's diagnosis and execution of an event. These underline the need to appropriately estimate HEP in risk analysis. There are several methods that are being practiced in Probabilistic Safety Assessment (PSA) studies for quantification of human error probability. However, there is no consensus on a single method that should be used. For accident scenarios, the data from real NPP control room is very sparsely available. In the absence of real data, simulator based data can be used. Simulator data is expected to provide a glimpse of probable human behavior in real accident situation even though simulator data is not a substitute for real data. The proposed methodology considers the variation in crew performance time in simulator exercise and in available time from deterministic analysis, and couples them through their respective probability distributions to obtain HEP. A validation exercise is carried out using hypothetical data and the results from proposed method are compared with those from Human Cognitive Reliability (HCR) model.

8.6.3 Estimation of Site Core Damage Frequency (SCDF)

The nuclear generating sites around the world are mostly twin unit and multi-unit sites. The PSA risk metrics Core Damage Frequency (CDF) and Large Early Release Frequency (LERF) currently are based on per reactor reference. The models for level 1 and level 2 PSA have been developed based on single unit. The Fukushima accident has spawned the need to address the issue of site base risk metrics, Site Core Damage Frequency (SCDF) and Site Large Early Release Frequency (SLERF), on the site years rather than reactor years. It is required to develop a holistic framework for risk assessment of a site which is capable of integrating the risk associated with all sources present at the site. There is currently no general consensus on how to arrive at site-specific risk metrics. This work proposes a method of aggregation of risk metric from the consideration of operating time of individual units under certain assumptions with a purpose to provide a new conceptual aspect for multi-unit PSA. The probability of core damage at a site is calculated as sum of the probabilities of core damages possible due to internal and external events. The common cause failure of units due to external event such as seismic activity or flooding is modeled. The result of a case study on hypothetical data shows that site level CDF is not sum of CDF of all units but few percentages higher than unit level CDF.

The other method developed is an integrated approach developed for risk assessment of a multi-unit NPP site taking into account most of the dependency classes and key issues applicable for a multiple unit NPP site such as initiating events, shared connections, cliff edge effect, identical components, proximity dependencies, mission times and human dependencies was used to compare the risk for sites housing single, double and multiple nuclear plants. From the analysis, it was observed that external events such as seismic and tsunami have high potential for multi-unit risk. This method helps in identification of critical structures, systems and components important for safety in multi-unit sites which are otherwise, overlooked by carrying out individual unit risk assessment. The method is also expected to be useful in developing safety goals, procedures and guidelines for a multi-unit NPP site. The outcome of such integrated PSA will also help in identification of those structures, systems and components that play important role in safety at multiple units and in regulatory decisions such as optimum number of units at a site, distance between two units, layout diversity and configuration of shared systems, etc. to minimize risk to the public and environment.

8.6.4 External flood PSA for PFBR

Based on the findings and recommendations that evolved from the Fukushima accident, AERB has undertaken external flooding PSA (EFPSA) of PFBR as a joint R&D exercise with participation of IGCAR, BHAVINI and BARC. The objective of the study was to evaluate plant response to external flooding events of different severity and estimate core damage and spent fuel damage probabilities due to these events. Probabilistic flood hazard assessment for tsunami, cyclone and intense precipitation were completed. Identification of critical structures, systems and components from external flooding perspective were completed based on detailed system analysis using event treeandfault tree approach. Plant walkdown was carried out to assess the 'as-is' status of the components and identifying the possible interactions and failure modes. Fragility assessment considering submergence failure

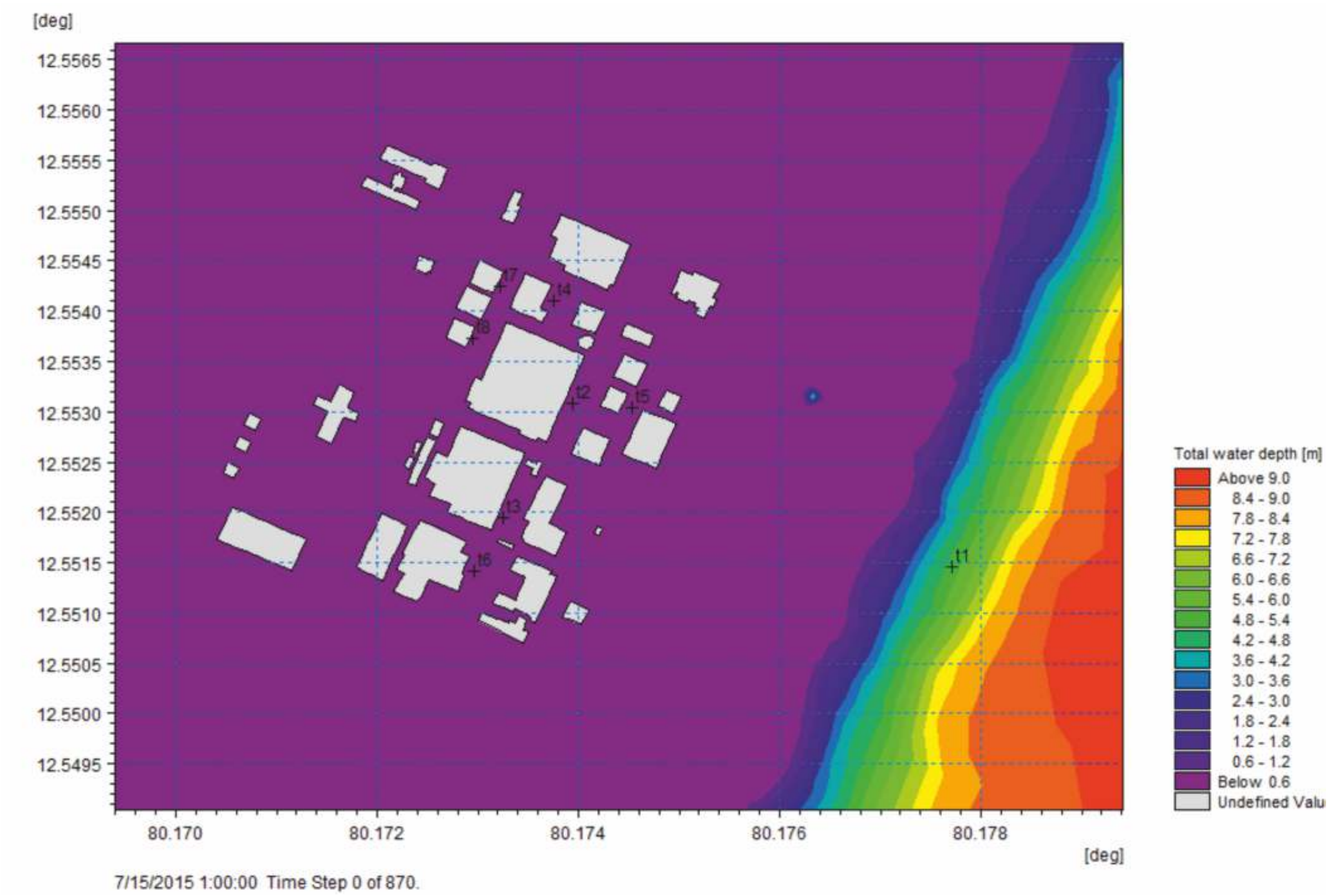


Fig. 8.6: Typical contour plot of water level within the site due to a scenario of tsunami

mode was undertaken to evaluate the component failure probability under different intensities of flood combined with random failure probabilities for the components. Evaluation of plant fragility and CDF due to flooding considering submergence failure was completed.

8.6.5 Flood routing studies for a coastal site

Probabilistic tsunami hazard assessment was undertaken for Kalpakkam site as part of external flood PSA. Tsunami wave time history is generated at control point within the sea based on a number of tsunami hazard analyses considering different source and rupture characteristics. Using the tsunami wave time history as input along with bathymetry data of the site area and elevations of plant buildings, flood routing was carried out to simulate the propagation of tsunami run up and inundation within the site. Around sixteen scenario tsunamis were considered in the analysis. Time history of water level and velocity around plant buildings were obtained from this analysis. A typical contour plot of water level within the site due a scenario tsunami is presented in Figure 8.6.

8.7 REACTOR PHYSICS STUDIES

8.7.1 Investigations on Neutronic Coupling Aspects of AHWR

Neutronic coupling is one the important core physics design consideration in power reactors. Degree of neutronic coupling depends on many parameters including core dimensions, shape, fuel moderator combination, neutron spectrum etc. Indian advanced heavy water reactor core is a large sized, heavy water moderated, light water cooled reactor core which may lead to spatial instabilities due to neutronic decoupling. A study was carried out for the quantitative estimation of neutronic decoupling in AHWR core through evaluation of higher harmonics of neutron diffusion equation. It has been found that due to small H/D ratio, azimuthal modes of AHWRs are relatively more decoupled and prone to spatial instabilities under certain conditions. Separation between axial and azimuthal harmonics has also been significant which ensures that core may not undergo multimode oscillation under a given asymmetric reactivity perturbation.EVS, Based on the above study, it was inferred that AHWR is neutronically more coupled than 500 MWe PHWR or 1000 MWe PWR, but is less coupled than 220 MWe PHWR.

8.7.2 Development of Computer Code for Linear Stability Analysis of Nuclear Reactors

Stable neutronic response of a nuclear reactor core is one of the important requirements for safe reactor operation. Analysis of reactor stability is necessary to demonstrate its ability to withstand reactivity perturbations encountered during the course of operation. In the present work, a general methodology was developed for linear stability analysis of nuclear reactors, wherein addition to fuel & coolant temperature reactivity feedbacks and xenon reactivity feedback has also been included. A methodology was established for identifying the stability region of a nuclear reactor, i.e. for identifying the region of permissible values of reactivity coefficients for stable operation. Equations governing the evolution of reactor power, fuel and coolant temperatures and xenon reactivity are based on point reactor model. These equations were linearized considering small deviations around the steady operating state. The characteristic equation of the system was obtained and used for identifying the stability region considering fuel and coolant reactivity coefficients as parameters. This methodology was illustrated for a typical pressurized heavy water reactor (PHWR). It was noted that local stability of the reactor is largely influenced by the parameters governing the evolution of fuel and coolant temperature and Xenon concentration rather than neutron kinetics parameters. It was also shown that positive reactivity feedback from xenon narrows down the region of stability. The analysis revealed that, at its typical operating point, a PHWR is inherently unstable due to Xenon feedback. A reliable external reactivity control system (Reactor Regulating System of PHWR) is required to maintain the reactor at steady operating condition.

8.7.3 Multi-point Kinetics Model for RELAP5

A user defined multi-point kinetics model has been developed to circumvent the inadequacy of point kinetics model of RELAP5 for analyzing postulated neutronic asymmetry power transient in loosely coupled reactor such as LOCA in one loop of 540 MWe PHWR. The neutron kinetics equations governing power of individual nodes were solved. Various decay heat models such as standard decay heat model of Way & Wigner, ANS 1973 model were incorporated in the multi-point formulation. The model was validated for AECL three dimensional kinetics benchmark problem in a heavy water reactor. The power estimates for nodes were compared with TRIKIN (in-house 3-D neutron kinetics) code. Multi-point results were in close agreement with 3-D code as can be seen in Figure 8.7. The validated Multi-Point kinetics model was used to identify the critical break in RIH with class-IV power unavailable. For this, a range of break sizes ranging from 5% to 100% of double ended guillotine rupture of RIH were analyzed for the large PHWR. A post processor code was developed to find out the maximum fuel clad surface temperature and its location in the core. To accommodate time evolution of core neutronic parameters in internode coupling coefficient, a fuel temperature and coolant density dependent array of coupling coefficient was included in the model. The study revealed that time updation of internode coupling coefficient does not lead to significant changes in nodal powers. This can be attributed to primary dependence of coupling coefficient on core geometry than core thermal state for the case considered.

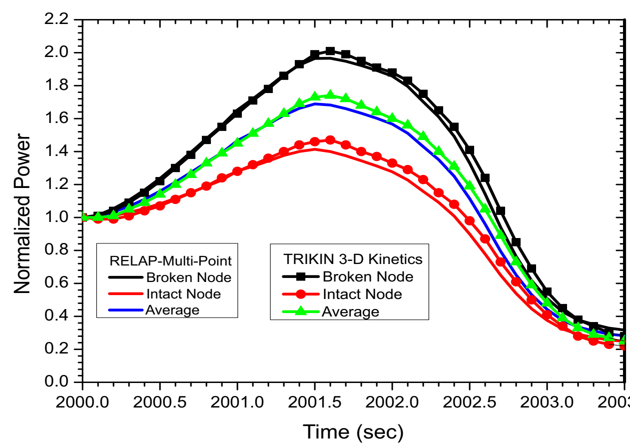


Fig. 8.7: Normalized Power in Multi-Point and 3-D Kinetics

8.7.4 Reactor Physics Analysis for Cycle-2 of KK VVER

As part of regulatory review of KK NPP unit-1, critical boric acid concentration was estimated for new core configuration cycle-2 of KK VVER Unit-1. Calculations were carried out for Hot Zero Power (HZP) conditions with different positions of Group-10 of Control Protection System-Absorber Rods (CPSARs) and for Hot Full Power (HZP) conditions with and without saturated Xenon. Cycle 2 core of KK VVER Unit-1 has attained criticality, whichhadthe critical boron concentration matching very closely with the predicted value. Reactor Physics analysis has also been extended to estimate critical boric acid concentration as a function of EFPD and reactivity loads such as Doppler, Coolant temperature and Xenon as a function of reactor power, worth of control rods and emergency protection system etc. for new core configuration of VVER KK cycle-2.Variation of reactivity load as a function of reactor power is presented in Figure 8.8.

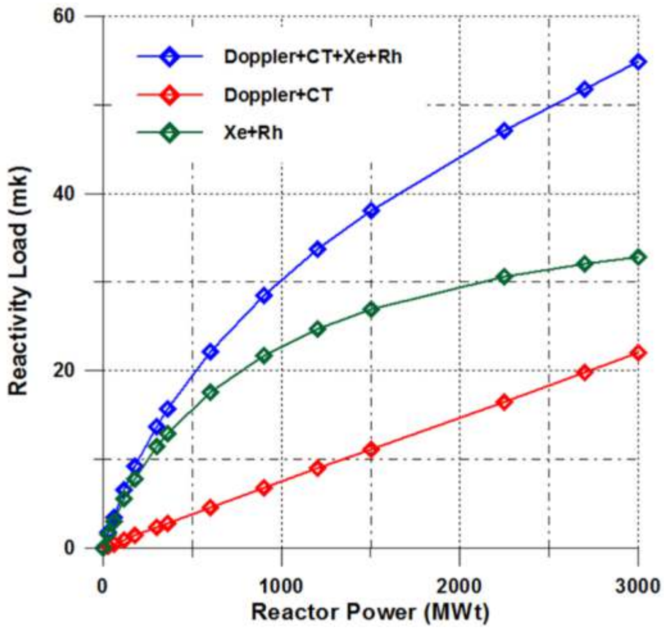


Fig. 8.8: Doppler, Coolant temperature and Xenon loads as a function of reactor power for Cycle-2 of KK VVER-1

8.7.5 Lattice Physics Calculations for 220 MWe PHWR using DRAGON Code System

Lattice physics calculations were carried for 19 element bundle of 220 MWe pressurized heavy water reactor (PHWR) for hot operating and isothermal cold conditions using a lattice burnup code DRAGON. Hot condition assumes fuel temperature of 625°C, moderator temperature of 54.4°C and coolant temperature of 271°C whereas cold condition considers 25°C for all materials. Reactor physics parameters like infinite neutron multiplication factor, two group homogenized cross-sections and isotopic composition of various nuclides were calculated as a function of burn up. Comparison of results of present simulations with the results of designer documents shows good agreement. Estimation of coolant void reactivity as a function of burnup was also carried out using theoretical calculations. The same hot operating and isothermal cold conditions were considered for the analysis. Nuclear data evaluations like ENDF/B-VI, JENDLE-3.0, JEFF-3.1, ENDF/B-VII.0 and ENDF/B-VII.1 were used in 69/172 groups to estimate void reactivity effects. Coolant void reactivity estimated using 172 groups were found to be larger in magnitude compared to those using 69 groups for both the conditions. Comparisons with the designer results using CLUB code showed good agreement.

8.7.6 Estimation of Instrumented Central Sub-Assembly (ICSA) Detector Counts ` during Fuel Loading at First Approach to Criticality (FAC) of PFBR

A set of calculations was carried out for safety assessment of the PFBR during initial fuel loading operations and First Approach to Criticality (FAC). The core status is to be monitored by observing the neutron counts in three high temperature fission counters mounted inside an Instrumented Central Sub-Assembly (ICSA) located at the core centre. Theoretical calculations were carried out to estimate the detector counts during every stage of fuel loading and for two sets of reactor configurations, i.e. all absorber rods fully inserted in the core and also out of the core.

The results were compared with the count rates predicted in the PFBR-PSAR chapter on reactor physics and found to match fairly well. The inverse count rates showed a concave slope, which is safer from operational point of view. By extrapolating the inverse count rates for all absorber rods out cases, the number of fuel subassemblies required for criticality was also estimated.

8.7.7 Evaluation of Shutdown Margins of PFBR at Different Stages of Fuel Cycle

The absorber rod worths and shutdown margins of 500 MWe Prototype Fast Breeder Reactor (PFBR) have been estimated independently for the beginning of cycle (BOC) and end of cycle (EOC) core during each cycle of refueling. This analysis has been carried out by coupling isotopic depletions with burnup and criticality calculations. The depletion of isotopes of fuel subassemblies in the core was calculated by using a burnup computational module. Using the isotopic number density obtained by the burnup analysis, criticality calculations were performed to compute the neutron multiplication factors (k-eff) and in turn the absorber rod worths. The calculated absorber rod worths and shutdown margins of the core have been compared with the results submitted by the designers.

8.8 FIRE SAFETY STUDIES

8.8.1 Independent Verification of Fire Hazard Analysis for KAPP-3&4 -700 MWe plant

Fire hazard analysis (FHA) is essential to assess the fire potential, fire potential strategy, detection mechanism and suppression means at various locations. The FHA for KAPP-3&4 was independently verified using fire influence approach (Fire Dynamics Tool-FDS) and fire compartment approach (Fire Dynamic Tool-FDT). Two important rooms namely, fuel handling control panel room and pump room were considered to analyse the impact of fire on surrounding equipment. Location of fire was selected appropriately to maximize severity of its impact. The estimated net heat flux values were below critical heat flux and estimated temperatures found to be in good agreement with the utility results.

8.8.2 Compartment Fire Test Facility (CFTF)

A state-of-the-art Compartment Fire Test Facility (CFTF) has been inaugurated at AERB's Safety Research Institute (SRI), Kalpakkam by Dr. R. Bhattacharya, former Vice Chairman, AERB on 30 Sep. 2015 in presence of Dr. S.A.V. Satya Murty, Director, IGCAR. The facility will be used for basic research in enclosure fires, investigation of mitigation methodologies & techniques, as well as to provide research based inputs for regulatory activities in the areas of fire safety.

Dr. R. Bhattacharya, Former VC, AERB and Dr. S.A.V. SatyaMurty, Director, IGCAR inaugurating the CFTF

A pool fire experiment in progress

A series of experiments are planned on basic research in enclosure fires, investigation of mitigation methodologies & techniques, and to provide inputs for regulatory activities in the area of fire safety. A hydrocarbon pool fire experiment was conducted to demonstrate the synchronized functioning of various components and instruments. Experiments on fire development as well as mitigation will be conducted using combustible fuels / solvents / solvent-mixtures that are employed predominantly in NPPs / fuel reprocessing units. The facility is equipped to undertake such studies. Specific experiments of regulatory interest will be taken up to provide necessary inputs. The data generated would be useful for the validation of computational fire modeling tools that are being developed / used. This data can also be used later for preparation/ upgradation of safety documents on fires.

8.8.3 Hot Cell Fire Safety Assessment

For the purpose of removal of sodium from a failed fuel subassembly (FSA), it is proposed to add a sodium cleaning system employing ethanol as the cleaning agent inside a hot cell at RML, IGCAR. Expert opinion of SRI on the issue of possibility of occurrence of fire within a hot cell under certain accidental conditions was sought by RML, IGCAR. To address this issue, numerical studies were carried out to determine the possibility of formation of flammable mixture and its ignition due to heat sources within the cell. Several CFD simulations were carried out to estimate the evaporation rates and possibility of vapour ignition under different conditions. Based on the findings, recommendations for safe operation and measures to avoid fire hazard were made.

8.9 STRUCTURAL AND SEISMIC ANALYSIS

8.9.1 Safety Assessment Methodology for Pressure Tube under Delayed Hydride induced Cracks in PHWR

Leak Before Break (LBB) is employed as a defense in depth to avoid unstable failures in Pressure Tube (PT). Delayed hydride induced cracks (DHC) is a sub-critical crack growth mechanism occurring in zirconium alloys as well as other hydride forming materials that requires the formation of brittle hydrides locally at the tip of the crack. DHC results in a radial

–axial crack. Consequence of DHC usually is leakage before rupture. Service induced / manufacturing flaws can act as a stress raiser in addition to residual stress in the rolled joint region. When a through wall crack is formed, leakage of PHT fluid starts into the PT-CT gap. Owing to very high pressure in the PHT system as compared to PT-CT Annulus Gas Monitoring System (AGMS) pressure, choked flow will occur from the crack. A postulated case of PT leakage was assessed using deterministic methods against unstable fracture of PT. Thermal hydraulic simulation was carried out for the postulated crack opening area in the PT using RELAP5. Two sub-cooled choked flow models, namely, Burnell and RELAP5 models were used for determination of crack area based on the postulated mass flow rate. Burnell model provides conservative predictions of break in terms of crack propagation. The break area is used to further estimate the crack length using Paris and Tada correlation for longitudinal crack. The stress intensity factor was calculated for longitudinal through-wall crack and compared with fracture toughness to ascertain the factor of safety. Critical crack length (CCL) was also obtained at reactor operating condition. The CCL parameter represents the maximum stable crack extension till catastrophic failure. If crack length in a PT is below CCL then LBB is assured. The maximum load carrying capability is derived using fracture toughness for irradiated pressure tube. The crack size showed that enough margin with respect to CCL is available and demonstrated PT structural integrity.

8.9.2 TAPS RPV Stress Analysis under Upset Condition

Thermal and structural behaviour of TAPS reactor pressure vessel (RPV) under transient condition was analysed to ascertain the stress distribution under upset loading condition. Detailed transient heat transfer analysis for heat up (start-up) condition was carried out and temperature distribution across the RPV thickness was evaluated. This temperature distribution was used as initial condition to perform the thermo-mechanical analysis of TAPS-1 RPV (clad and base material) for upset loading condition using ABAQUS. Temperature and hoop stress distribution was calculated and it was observed that hoop stress at inner surface was in tensile nature and compressive at outer surface. A stress linearization procedure was used for stress classification (membrane and bending stress) across the RPV wall thickness (clad & base metal). Mesh sensitivity analysis was also performed to get the optimum mesh size for the analysis. Stress classification (membrane and bending stress) was used for structural integrity assessment for the RPV as per the ASME section XI.

8.9.3 Assessment of Structural Integrity of Calandria Vessel during Core Melt Event

A beyond design basis accident in PHWR may result in severe core damage and subsequent formation of molten corium at the bottom of the calandria vessel. Efficient removal of decay heat from molten corium is possible if nucleate boiling conditions prevail at the outer surface of the submerged calandria vessel. However, if this heat removal is constrained, the transition from nucleate boiling to film boiling may be attained at a lower heat flux, leading to early degradation of the vessel. The objective of the numerical study was to estimate the calandria vessel integrity under such accidental conditions. Several parametric studies were conducted using various applicable pool boiling correlations as a function of wall temperature. Under simulated conditions with nucleate boiling, it is observed that creep and plastic strains developed in the vessel is insignificant. The maximum corium temperatures in the central and top region were estimated. Under severely compromised conditions with critical heat flux being reached, the temperature limits in the vessel are exceeded. However, this condition is highly unlikely as transition from nucleate to film boiling phenomenon takes place if calandria submergence is lost.

8.9.4 Design of Core Melt Retention Facility (COMREF) Test Facility

To investigate the behavior of calandria vessel during core collapse accident, Core Melt Retention Facility (COMREF) is being designed. The objectives of Phase-I experiments is two folds; (a) to demonstrate the ability of the calandria vessel to act as core catcher, (b) to evaluate the effective heat transfer coefficients at the outer surface of calandria vessel. Numerical analysis has been carried out to evaluate the design basis temperature, heat flux and power requirement. A safety report has been prepared, highlighting the objectives of experiment, salient features of the facility, design basis, instrumentation plan, and safety related features incorporated in the design of the facility.

8.9.5 SRI Engineering Hall

An engineering hall is being set up under the XII plan. This building consists of a high bay a low bay, an office space and an entrance lobby. As of now, three experimental facilities, namely Hydrogen Mitigation Facility (HYMIF), Water and Steam Interaction Facility (WASIF) and Core Melt Retention Facility (COMREF) facility are envisaged to come up within the high bay of the hall. Radiation shielding experiments will be carried out in the low bay. The civil and electrical works related to the Engineering hall building have been completed. The front view of the SRI Engineering Hall is shown in Figure 8.9.

Figure 8.9 Front view of the SRI Engineering hall

8.9.6 Water and Steam Interaction Facility (WASIF)

An experimental facility is planned in collaboration with RSD, BARC to investigate various types of direct contact condensation (DCC) including condensation induced water hammer (CIWH). Specific phenomena that are encountered during the functioning of safety systems in thermal reactors will be addressed. WASIF will be setup within the high bay of the SRI engineering hall. The design safety report for this facility is ready. A few instruments have been delivered at SRI. Indent for steam boiler along with those for several other instruments has been raised. The proposal for fabrication work is under preparation.

8.10 RADIOLOGICAL ASSESSMENT AND ENVIRONMENTAL SAFETY STUDIES

8.10.1 Estimation of Heat out-Flux from Vitrified Waste Canister

High-level waste generates intense levels of both radioactivity and heat. Heavy shielding and cooling is required during its handling and temporary storage and hence, the wastes are stored in engineered barriers. Quantification of heat out-flux from the waste canister is essential during the storage and the disposal stage to establish the safety of the waste containment as well the impact to the environment. For the study, a 2D heat conduction equation was formulated in cylindrical co-ordinate and the governing equation was evaluated numerically by using finite difference method. The heat generation rate in the waste is a function of the mass of the radio nuclide inventory. Two decay heat algorithms were used, one each for the heat generation from the beta and gamma radiation. In developing these models a total of 26 fission and activation products were considered. The heat out flux from the scale down waste canister was estimated for a period of 3 years, for different initial waste loads 2400 Ci, 4800 Ci and 7200 Ci are shown in Figure 8.10.

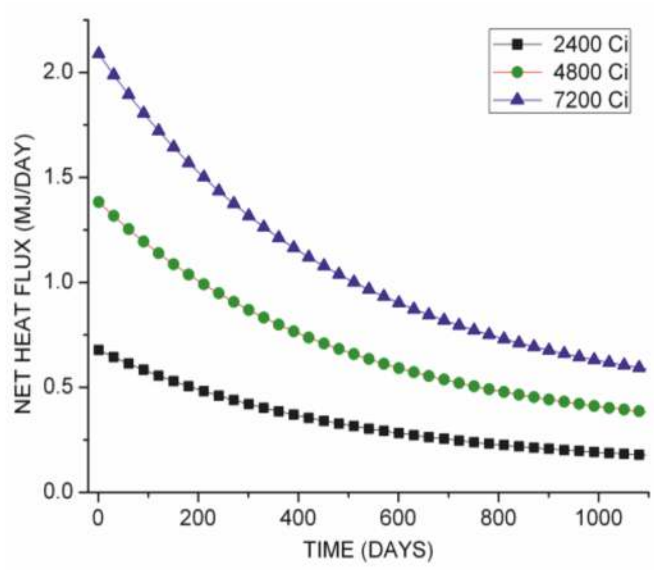


Fig.8.10:Heat flux for different initial waste inventory loads

8.10.2 Determination of Downwind Species Concentration under Plume Reflection from a Low Lying Inversion Layer

Vertical temperature structure of the atmosphere significantly influences the species dispersion. When a temperature inversion forms a convective or neutral layer above, it acts as a cap and reflects species plume to the ground. The pollutant gets mixed in the convective region between the ground and the inversion layer and is called the mixing height. Estimation of downwind pollutant concentration without taking in to account of the mixing height results in underestimation of pollutant concentration. For the estimation of downwind concentration, a plume reflective term was added to the in-house Gaussian plume model and the downwind ^{131}I concentration was estimated for different inversion layer heights. The downwind concentration estimated for continuous release of ^{131}I at the rate 30Bq/s in the absence and presence of inversion layer heights at 75 and 125m is shown in Figure 8.11. The source release height is assumed to be 50 m. Presence of low lying inversion layer was found to significantly influence the downwind pollutant concentration.

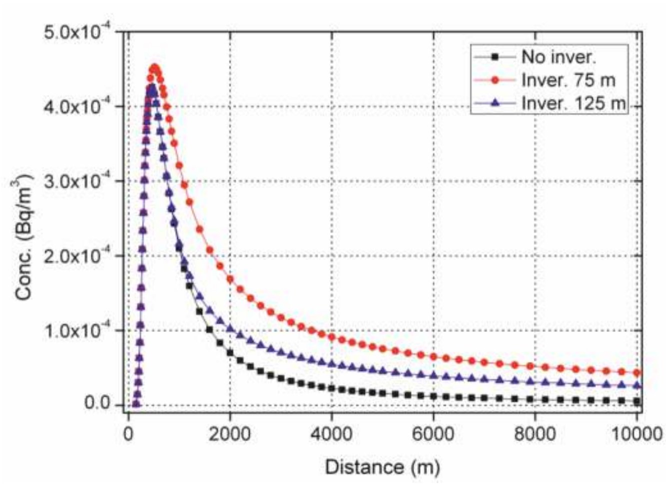


Fig.8.11: Ground level 131I concentration for different mixing layer heights for stability Class C

8.10.3 Computation of Wind Profiles in the Surface Layer using Meteorological Observations for Wind Field Study

Interaction of winds with the surface of the earth results in the formation of a boundary layer in proximity to the ground called Atmospheric Boundary Layer (ABL) or Planetary Boundary Layer (PBL). Bottom 10% of the ABL is called the Surface Layer (SL). Computation of turbulence parameters in the surface layer is essential for pollutant transport studies. It includes frictional velocity, u^* mixed layer scaling temperature, q^* Monin-Obukov length (L) and vertical heat flux (H). Direct measurements of these parameters require fast response turbulence measuring instruments. In the absence of such measurements, turbulence parameters can be estimated from wind and temperature measurements in the surface layer by using the profile relationships. In this study, turbulent parameters were estimated by using profile method for the Kalpakkam site and meteorological tower data. Estimated surface parameters were then compared against that computed by using reliable Eddy Correlation Method (ECM). It is found that u^* correlate well for smaller z/L for stable atmosphere. For larger z/L values profile method under predicted the value. For unstable atmosphere, profile method overestimated the values of for two different data sets. If wind speed and potential temperature measurements at one level and turbulence parameters are estimated by more reliable ECM, it is possible to estimate the wind speed and potential temperature at any other level in the surface layer by using the profile relationship. To check the validity of the profile relationship, wind speed and potential temperature measurement at 2m height was used and the corresponding variable at 16m level was estimated for Kalpakkam site. Comparison of estimated and measured parameters showed very good agreement for unstable atmosphere.

8.10.4 CFD studies on Reaction Product Discharge Circuit (RPDC) of PFBR

A study to investigate the possibility of air ingression into the secondary sodium tank through the chimney of the RPDC of PFBR has been completed. A 2D model of the chimney was developed and CFD analysis with respect to different inlet argon velocities (0.05m/s to 1m/s) and various inlet temperatures (423K-523K) has been carried out. Even though the argon density at higher temperature is lesser than the air density at room temperature, the analysis indicated that the possibility of air ingression into the system is negligible. This is because the air entering the chimney is getting heated up and circulated back at the exit of the chimney itself.

8.10.5 Nuclear Emergency Management Information System (NEMIS)

As a continuation of the development of decision support system for emergency preparedness, site specific information is being included into the system periodically. Necessary data for Kaiga site is added into the database. The site specific data include constituent villages around 16 km area of KGS, population details of 2011 census data, information on rallying posts, hospitals, transport facility etc. collected from different

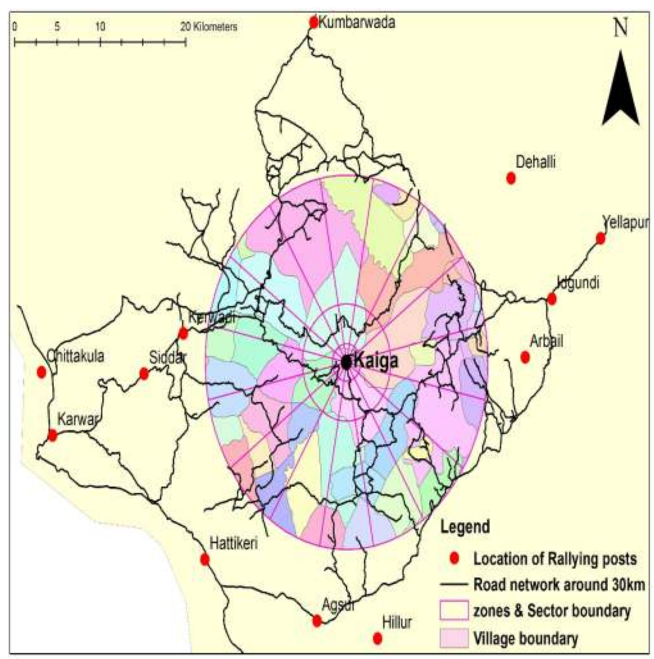


Fig. 8.12: Locations of rallying posts, sectors, zones, village boundary of emergency planning zone(16 km radius) and road map (30km radius) around Kaiga

agencies are converted in geo-databases to shape files.

Shape files on sectors and zones has been created with respective data available in AERB manual. A map on village boundary with population details of 2011 census data and rallying posts has been created for the emergency planning zone. As shown in Figure 8.12, there are 46 villages located in the emergency planning zone and 13 rallying posts identified for Kaiga site. Also, for the third phase of the decision support system being developed, as part of emergency response module, shortest path identification method using network analysis in ArcGIS module is being studied using geo database analysis.

8.10.6 Study on Combined (PFBR-MAPS) Discharge Channel

As part of environmental safety studies, a study was carried out on the combined (PFBR – MAPS) discharge channel. The satellite data collected after the construction of combined discharge channel (from 2011 to 2015) shows that during January-March, deposition takes place along north side and erosion occurs on the south side of the canal. During August-September erosion takes place along north side of the canal whereas deposition takes place along south side of the canal which shows the strong influence of prevailing sea current in this area. The study also indicates that there is no adverse impact on the surrounding hamlets. Figure 8.13 shows the pattern absorbed.

Fig. 8.13:Sedimentaccretion-erosion pattern along combined PFBR-MAPS discharge canal with respect to season

8.11 STUDIES PERTAINING TO THE BACK END OF THE FUEL CYCLE AND SOIL REMEDIATION

8.11.1 Application of Electrochemical Methods for Removal of Radionuclides

In order to evaluate the application of electrochemical methods for the removal of radionuclides, removal studies of cesium from aqueous stream was taken up. Inactive Cesium (500ppm) in aqueous stream was employed as the electrolyte and the required voltage was supplied using DC power supply unit. Determination of Cs remaining in the aqueous stream was determined using Atomic Absorption Spectrometer (AAS). Initial studies were carried out using SS electrodes with different surface area. To understand the influence of clay colloids, a set of experiments were carried out at various amounts of clay colloids with fixed voltage applied between electrodes dipped in electrolyte containing known concentration of Cs. It was found that removal of Cs from aqueous stream increase with clay amount but up to a certain limit and factors such as applied voltage, electrode configuration and supporting electrolytes were found to influence the Cs removal. Electrochemical destruction of organic effluents such as oxalic acid was also successfully demonstrated at SRI Chemistry laboratory.

8.11.2 Uptake of Radionuclides using In-house Synthesized Biopolymers

Biosorbents and dead biomasses also are promising candidates for the removal/speciation of heavy metal toxic ions from aqueous solutions as well as removal of radionuclides from nuclear waste streams. The selectivity of these biosorbents depends upon their thermal and radiation stability. Novel biopolymers such as Chitosan find extensive applications as an adsorbent due to the presence of amide groups in its structure. Due to its flexibility to employ the polymer in variety of forms, chitosan can be prepared as microspheres for column applications. Chitosan microspheres are synthesized at Safety Research Institute (SRI) of AERB wherein, chitosan in glacial acetic acid was dropped in

0.5M NaOH to form uniform chitosan beads which was cross linked with glutaraldehyde. Zirconium cross linked chitosan was synthesized by adding chitosan and zirconium oxychloride (0.1M) in required amounts and the final Zr-CTS composite was precipitated and cross linked with 5% glutaraldehyde. Uptake of Cs and Ru were successfully demonstrated at SRI by taking 1000mg/L of Cs and Ru solutions. While the estimation of Cs was carried out using Atomic absorption spectroscopy (AAS), estimation of Ru was carried out using inductively coupled plasma emission spectroscopy (ICP-OES)

8.11.3 Degradation of Epichlorohydrin and Textile Effluent using Photocatalytic Route

Oxidative degradation of toxic and environmental pollutants using environmentally benign technologies such as Advanced Oxidation Processes (AOPs) is being pursued at AERB's SRI, Kalpakkam. The carcinogenic and toxic chemical, Epichlorohydrin is an environmental pollutant and is employed as a cross linking agent besides its applications in nuclear industry. Degradation of epichlorohydrin was successfully demonstrated using photocatalytic route at SRI chemistry laboratory. 500mg/L epichlorhydrin was taken for the degradation study and 50mg/L of titania was used as the photocatalyst. Degradation of epichlorohydrin was followed using gas chromatographic route and more than 95% degradation could be achieved in 240 minutes of irradiation. Degradation of epichlorohydrin was followed by a gas chromatographic procedure and the degradation was found to follow pseudo-first order kinetics. Textile effluent containing many dissolved toxic organics as well as pungent odour was received at SRI from BARC. The same was successfully degraded using nanoparticles of titania using photocatalytic route. Extent of degradation of the effluent was determined using the decrease in Total Organic Carbon (TOC) values.

8.11.4 Characterization of TENORM Samples

In order to frame guidelines for regulating the TENORM and NORM generated in oil and industry, AERB has constituted a technical committee on Oil and Gas to look into the issues related to their disposal and minimizing contamination to the workers and to the environment.TENORM samples have been received at SRI from ONGC Basin, Karaikkal including Sludges from Effluent Treatment Plant (ETP) and scales from the discarded pipelines. The samples were characterized using HPGe detector at SRI and determination of ^{226}Ra was carried out using an in-growth method by following the gamma peak of ^{214}Bi. As per the guidelines of Oil and Gas Committee, technical note on "Protocol for monitoring and measurement of NORM in oil and gas industry" was prepared. A portable radon monitor with scintillation detector is deployed to monitor radon concentration in environmental soil samples and TENORM samples regularly as shown in Figure 8.14.

8.11.5 Thermokinetic Behavior of Novel Extractants and Adsorbents used in Nuclear Fuel Cycle

After gaining sufficient expertise in the thermo kinetic behavior of Tri-n-butyl phosphate (TBP), its degradation products and the factors responsible for the formation of reactive red oil forming substances, thermokinetic behavior of novel extractants and diluents used in the back end of the fuel cycle was taken up at Safety Research Institute (SRI) of AERB in collaboration with CLRI, Chennai. TEHDGA (Tri-ethyl hexyl Diglycolamide), extractant identified for the extraction of minor extractants from high level liquid waste was taken up for the thermal degradation studies. In order to simulate the exact composition of the extractant used for the process, accelerating rate calorimetric studies of 0.4M of the extractant in dodecane and imidazole diacetic acid was taken up. The samples were supplied by WMD, BARC and the studies were carried out at CLRI, Chennai. It was observed that the self heat rate and pressure rise profiles were prominent when the amides are used in the presence of nitric acid compared to the extractant alone. Thermokinetic behavior of these novel extractants would give useful information regarding their incineration behavior in the presence of acid, metal ions etc.

Phyto-extraction Studies for the Remediation of Contaminated Soil

Phytoremediation would play a vital tool in sustainable management of contaminated soil. Phytoremediation can be defined as the efficient use of plants to remove, detoxify or immobilize environmental contaminants in a growth matrix (soil, water or sediments) through the natural biological, chemical or physical activities and processes of the plants. Phytoremediation involves growing plants in a contaminated matrix, for a required growth period, to remove contaminants from the matrix, or facilitate immobilization or degradation of the pollutants. The plants can be subsequently harvested, processed and disposed. Considering the importance of the remediation of contaminated soil and water using phytoremediation, R&D works are initiated and uptake studies of non-

Fig.8.14: Determination of radon concentration using Radon Monitor

radioactive cesium was demonstrated by planting plants such as Brassica juncea (Indian Mustard) and Helianthus annus (Sunflower). The uptake was found to be goo using Brassica juncea in the shoot system and works are in progress to find out the influence of fertilizers and other salts for the uptake of Cesium. Studies are also in progress for carrying out phytoextraction studies for the uptake of radionuclides in collaboration with CWMF, BARC.

8.12 AERB FUNDED SAFETY RESEARCH PROGRAMME

To promote safety research and related activities, a Committee for Safety Research Programmes (CSRP) had been constituted by AERB 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 CSRP met four times during the year and approved six new projects.It also approved the renewal of 12 ongoing projects. The details are given in Tables 8.1 and 8.2.

In addition, financial support was provided to 35 seminars, symposia and conferences.

Table 8.1: New Research Projects Approved

S. No.	Project Title	Principal Investigator	Organization
1.	Studies on adsorption characteristics of radionuclides by phyco-colloids of seaweeds	Dr.L. Stanley Abraham	Satyabhama University, Chennai
2.	Studies on microbial diversity and ecology in the vicinity of a coastal NPP in relation to water quality and. nutrients	Dr. S. Karutha Pandian	Algappa University, Karaikudi, Tamilnadu
3.	A Study on the role of colloids in the transport of radionuclides in water	Dr. S. Chidambaram	Annamalai University, Tamilnadu
4.	Development of a neutron dosimetric technique using prompt gamma measurements	Dr. Pradip Sarkar	Manipal University, Karnataka
5.	Synthesis of Chitosan based poly electrolyte ultrafiltration membrane for the remediation of radioactive Cesium from aqueous media	Dr.M. Dharmendira Kumar	Anna University, Chennai
6.	Studies on environmental radioactivity levels in and around Chitrial uranium mineralized areas of Nalgonda District, Telangana State, India	Dr. Ch. Gopal Reddy	Osmania University, Hyderabad

Table 8.2: Research Projects Renewed

S. No.	Project Title	Principal Investigator	Organization
1.	Radiation Doses and its Impact from Radiological and Cardiological Interventions	Dr. Roshan S. Livingstone	CMC, Vellore
2.	Leukocyte DNA damage as a biomarker for radiation exposure to patients undergoing MDCT examinations	Dr. Anupama Tandon	UCMS & GTB Hospital, Delhi
3.	Effect of Radiolytic Products and Metal Nitrates on Red oil Forming Reactions	Dr. M. Surianarayanan	CLRI, Chennai
4.	Studies on levels and effects of natural radiation in the environment of different regions of Manipur	Dr. S. Nabadwip Singh	Oriental College, Imphal
5.	Image Quality/Patient – Staff Dose Studies & Development of Dose Audit Procedures in Interventional Cardiology	Dr. K. N. Govindarajan	PSG Hospital, Coimbatore
6.	Synthesis and Characterization of Al2O3 for Ion Beam Dosimetry	Dr. K. R. Nagbhushana	PES Institute of Technology, Bangalore
7.	Development of a Standardized Thermal Infrared Imaging Technique for Monitoring Temperature Distribution at Power Plant Outfall Sites	Dr. Usha Natesan	Centre for Water Resources, Anna University
8.	Fabrication of Nano oxide based Sensor on Stabilized Nano Zirconia for Detection of Hydrogen Sulfide	Dr. T. M. Sridhar	Rajalakshmi Engineering College, Chennai
9.	Thermo luminescence Characterisation of phosphors used in display devices for possible use in accident dosimetry	Dr. A.S. Sai Prasad	Vasavi College of Engineering, Hyderabad
10.	Development of novel polymeric detectors for selective dosimetric analysis	Dr. V. S. Nadkarni	Goa University, Goa
11.	Estimation and analysis of radiation doses associated with interventional cardiology and other fluoroscopy guided procedures	Dr. Satish C. Uniyal	Himalayan Institute of Medical Sciences, Dehradun (Uttarakhand)
12.	Study of Radiation Safety measures of X-ray Installations in Mizoram	Dr. Kham Suan Pau	Mizoram State Cancer Institute Campus, Mizoram

Chapter 9 Public Information

AERB has the mandate to keep the public informed on radiation and nuclear safety related matters. AERB views public outreach as an essential element to build a long lasting trust and confidence with media and the public, at large. Towards this, AERB has been maintaining a website with all relevant and updated information; issuing press releases on contemporary issues; publishing Annual Reports, Annual Bulletin and Newsletters. AERB has stepped up drive to address public concerns and provided information to the public through print and electronic media on various topics of public concerns.

The Annual Reports and Annual Bulletins contain information of various activities carried out by AERB during the year in pursuance of its mission, roles and responsibilities. AERB Newsletters, published every six months contains, in addition to above, technical and awareness articles in areas of nuclear and radiation safety.

AERB, also, as and when required, conducts press conferences and/or media briefings on the different topical issues.

As a step forward towards public consultation, AERB has formally introduced a mechanism for public participation in framing of its regulations by uploading draft Safety Codes on its website for public viewing and comments.

9.1 PRESS RELEASES

AERB issues press releases with an aim to keep members of public informed about its important activities. The press releases are issued in English as well as Hindi. During last year, twelve press releases were issued:

i. AERB conducts surprised inspections of medical diagnostic facilities at Mumbai and Navi Mumbai **issued on April 17, 2015.**

ii. AERB Industrial and Fire Safety Awards **issued on April 27, 2015.**

iii. Information regarding False Alarm on Radioactivity Leakage from Consignment that arrived at Indira Gandhi Cargo Terminal, New-Delhi **issued on May 29, 2015.**

iv. AERB grants License for Regular Operation of Kudankulum NPP Unit #1 and Consent for Siting of four more Indigenous Nuclear Power Units in Haryana **issued on July 14, 2015**.

v. AERB shuts down operation of some of the medical diagnostic X-ray facilities at Hyderabad owing to non-compliances **issued on July 27, 2015.**

vi. AERB shuts down operation of some of the medical diagnostic X-ray facilities at Bengaluru owing to non-compliances **issued on August 21, 2015.**

vii. Information on appointment of new Chairman of AERB **issued on September 1, 2015.**

viii. AERB's stand on non approval of routine dental X-ray examinations for age determination **issued on September 4, 2015.**

ix. AERB's enforcement actions against medical x-ray facilities at Delhi and Kolkata owing to non-compliance to regulatory requirements **issued on September 24, 2015**.

x. AERB releases the Annual Report for the year 2014-2015 **issued on September 24, 2015**.

xi. AERB receives the "SKOCH Smart Governance Award-2015" during the 41st summit of SKOCH summit on Transformative Governance **issued on September 24, 2015**.

xii. Shut down of KAPS Unit-1 following an incident of leakage from coolant system **issued on March 11, 2016 followed by regular updates.**

With regard to an incident of leakage from coolant system KAPS Unit-1, AERB promptly issued a press release on the safety status of the plant and functioning of respective safety systems. Thereafter, AERB kept the public/media engaged by issuing updates on the incident till the leak was plugged.The updates addressed the status of reactor safety, radiation exposure to workers and public, identification of leak and its rectification and termination of plant emergency at KAPS unit – I. The proactive steps taken by AERB for communicating the safety status helped to a large extent in allaying the apprehensions of fear and rumors among public.

Detailed press releases are available on AERB website

9.2 COMMUNICATION AND CONSULTATION WITH STAKEHOLDERS

AERB provides all necessary information to its stakeholders through its periodic newsletters, annual reports, web-site, press releases/ briefings and media interviews. The AERB annual reports contain information on safety status of nuclear & radiation facilities and findings of regulatory reviews. It also includes information on safety significant events reported by licensee and the regulatory inspectors. AERB website plays a pivotal role in keeping the public informed on issues related to radiological safety, major regulatory decisions and special technical reports etc.

Information on operating nuclear power plants including, validity of operating license, Regulatory Inspections, Significant Events, radioactive effluent discharges, occupational exposures, rated power capacities of all operating NPPs etc. are provided on the AERB's website and these information's are updated on quarterly basis.

The AERB Bulletin, which is the popular version of the Annual Report of AERB, presents the most important activities in a more understandable and public friendly format. AERB sought the views/ comments from public and other interested parties on the draft of the newly developed regulatory documents towards assessing the effectiveness of such process.

AERB publishes 'Newsletter' once in every six months. It provides a glimpse of the important regulatory activities conducted during the period along with important technical and awareness articles. During the year AERB published its newsletter Vol. 28 (1), January – June, 2015 and Vol. 28 (2), July – December 2015 in English. The Newsletters are uploaded on AERB website.

AERB has recently established a mechanism for obtaining comments from the general public on draft Safety Codes. From October 2015 onwards, the draft documents are being posted on the website of AERB for public comments. During the period, four draft safety codes applicable in Medical and Industrial Applications were made available in the AERB website for public comments. The comments received from the public were incorporated after review.

9.3 PUBLIC/STAKEHOLDERS AWARENESS PROGRAMS

AERB pursues its public outreach activity with an aim to reach out to various stakeholders of AERB and bring awareness on the aspects of nuclear, radiation & industrial safety. It also helps in making AERB's safety oversight and review process more visible. Apart from the activities like publication of annual report, newsletter, updating website, providing response to RTI and parliament questions, etc., the following public outreach activities were carried out by AERB.

9.3.1 Stakeholder Awareness Programs

There has been an accelerated growth in the application of ionising radiation technologies in the fields of medicine, industry and basic research in the country. With the increased beneficial use of radiation sources, there is concern about the likelihood of harmful effects of radiation. Apart from effective regulatory controls in place, AERB primarily focused on enhancing awareness on safe usage of radiation sources amongst stakeholders. Towards this, AERB routinely conducts awareness programs to a wide variety of audience with the specific objective of spreading the importance of radiation safety. These include the radiation workers, manufacturers/ suppliers of equipment, personnel from the industry, university faculty & students. Following is the list of awareness programmes conducted by AERB during the period.

Area	Topic	Target audience	Importance
Industrial Radiography	Online demonstration of e-LORA for end user module of industrial radiography practice on April 2015 Similar demonstration was carried out in Trichy in June , 2015	About 100 participants from various industrial radiography institutions have attended the programme. Officers from AERB demonstrated the e-LORA system through VPN network (online).	This programme offered widespread publicity of e-LORA among industrial radiography personnel / institution. Radiography personnel and radiography institutions cleared their doubts through interaction with AERB officers.
	Refresher programme Basic radiation safety and security and the applicable regulatory requirements on December 2015.	Radiography personnel (Radiographer/Site in Charge) who were not in the field for more than 5 years	To update understanding in basic radiation safety and security and the applicable regulatory requirements of the personnel before rejoining the industrial radiography field
Ship Recycling Activity at Alang	Radiation Safety vis-à-vis radioactive sources generated due to ship dismantling activities	Safety Supervisors: about 70 Nos.	To enhance awareness about metal contamination amongst the Ship recyclers.
Container scanning	Radiological safety in handling of container scanners conducted in July 2015.	About 15 Customs officials participated in the programme.	Enhancement of radiological safety.
Nuclear Medicine	One day discussions meet on supply of radioactive consignments for nuclear medicine held in August 2015.	Around 40 suppliers and Nuclear medicine professionals.	To enhance good safety practices in transportation and effective implementation of regulatory measures at manufacturer and supplier level to prevent any unusual incidents.

Nucleonic Gauges and Industrial Radiography	Two days Awareness Programme on "Radiation Safety & Security and Regulatory Aspects in Industrial Radiography and Nucleonic Gauge Practice" conducted at training Centre of M/s Hindustan Petroleum Corporation Limited (HPCL), Nigidi, Pune during November 23 and 24, 2015.	About 26 RSO, Service Engineers, maintenance personnel of nucleonic gauge and Site In-charge of Industrial Radiography were participated.	Enhancement of Radiation Safety
Metal recycling industries	Awareness program for Metal recyclers.	Meeting with Chief Factory Inspectors of all the states of India, conducted by Director General of Factory Advisory Services and Labor Institute	The meeting was regarding the amendment of Factories Act, 1948. This amendment will bring out a requirement of mandatory possession of radiation survey meters by various stake holders of metal recycling industry to avoid issues of metal contamination.
Diagnostic Radiology (DR)	Training Program on e-Licensing of Radiation Applications (eLORA) module for DRS/RSA States during September 29 & 30, 2015.	Detailed demonstration of eLORA module for users and regulatory inspection was provided by the DR group members.	Total 9 members form 5 DRS/RSA states participated in the program.

9.3.2 Advertisements:

AERB publishes advertisements in print media once every six months in order to sensitize the users on requirements of obtaining regulatory consent from AERB for use of medical x-ray equipment as well as for users of radioactive sources or radiation generating equipment.

9.3.3 Participation in Science and Technology Fairs

AERB participates in science and technology fairs where it displayed exhibits on the safety and regulatory aspects of Nuclear & Radiation Facilities including its safety documents. The exhibits were aimed at giving a correct perspective on radiation doses received and provide public, a glimpse of the technical aspects of regulation. The response to the AERB's exhibits at these science fairs was extremely encouraging with visitors of various age groups and students visiting the stall and getting informed about AERB and its role. During the period, AERB displayed exhibits and interacted with public at following events:

- 32nd DAE Safety and Occupational Health Professionals Meet at RRCAT, Indore (October, 2015)
- Indian Nuclear Energy-2015, Nehru Centre, Mumbai (October, 2015)
- International Workshop on NPPs: Safety & Sustainability (CANSAS 2015 & IW-NRTHS - 2015) (December 2015).

9.4 PARLIAMENTARY QUESTIONS

Fifty one parliament questions and sub questions related to regulation of Nuclear and Radiation Facilities were received and replied during the period.

9.5 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. The total number of RTIs handled during this period was one hundred and forty six of which eighty one RTIs were related to the radiotherapy practice. Year wise RTI queries replied by AERB is given in Figure 9.1.

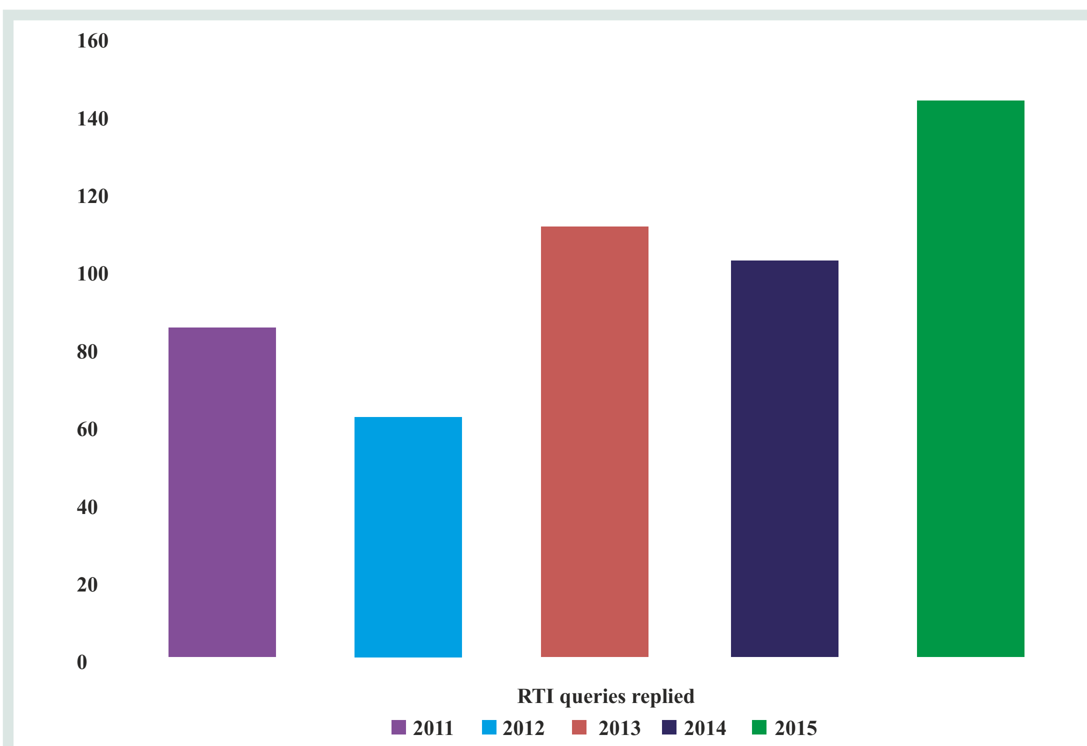
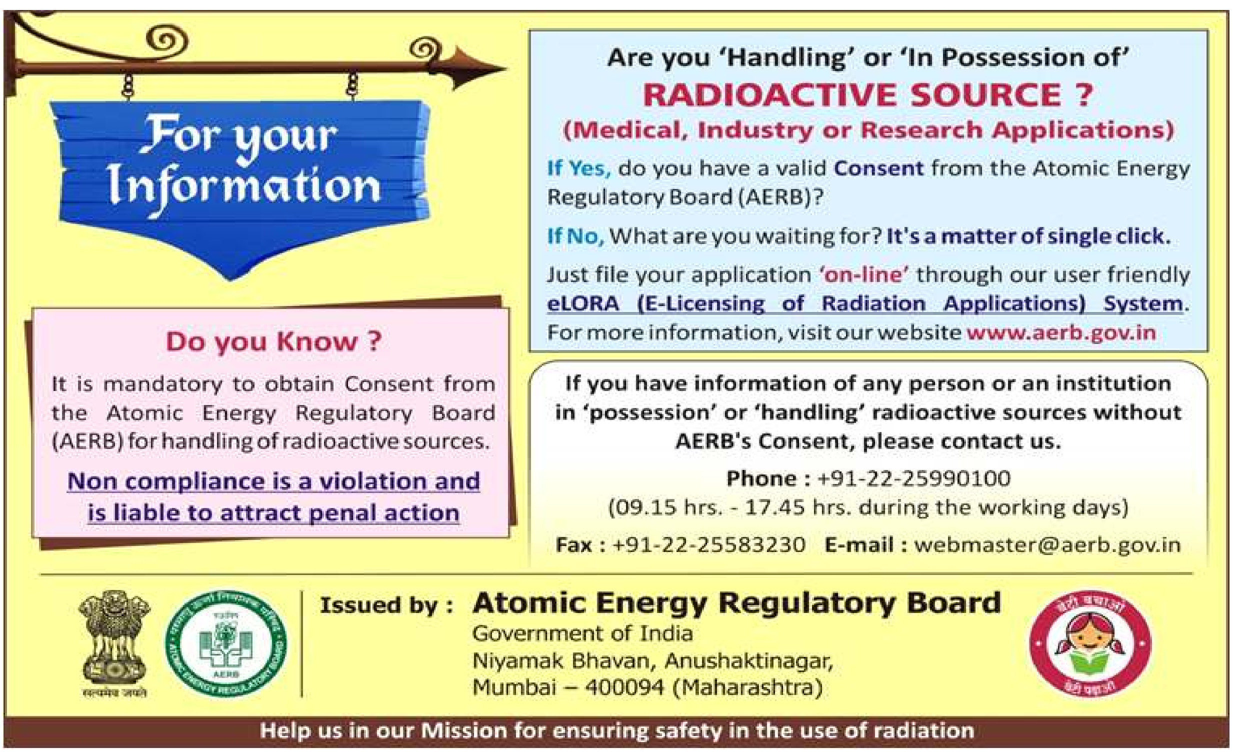


Fig. 9.1: RTI queries replied during the last 5 years

The Images of AERB officials conducting programmes



AERB's advertisement on handling of radioactive sources published in leading nation wide news papers

Chapter 10

International Cooperation

AERB recognizes international cooperation as a measure for enhancing effectiveness of regulatory control and harmonizing international regulatory practices and accords due importance to the same. India is a contracting party in the framework of several international instruments promulgated for establishing a global regime for cooperation in promoting safety in various nuclear/ radiation facilities/ activities. During the reporting period, AERB took several initiatives as to enhance its contribution in harmonization of international regulatory practices and methodologies and continued its participation in various international forums. AERB has also entered into bilateral arrangements/ agreements with the regulatory authorities of several other countries.

AERB, in association with Indian Nuclear Society (INS) and other units of Department of Atomic Energy (DAE), organized an international workshop on the theme 'NPPs: Safety and Sustainability' at Mumbai.

10.1. STRENGHTHENING NUCLEAR SAFETY AND SECURITY

10.1.1. Hosting of International workshop 'NPPs: Safety and Sustainability'

AERB in association with Indian Nuclear Society (INS) and other units of Department of Atomic Energy (DAE) organized an international workshop on the theme 'NPPs: Safety and Sustainability' at Mumbai during December 8-11, 2015. The workshop combined two international workshops, 'CANDU Safety association for Sustainability' (CANSAS-2015) and 'New Horizons in Nuclear reactor Thermal-hydraulics and Safety' (IW-NRTHS).

CANDU Safety Association for Sustainability (CANSAS) is a forum for sharing expertise among the nuclear safety experts from countries operating Pressurized Heavy Water Reactors (also known as CANDU reactors). CANSAS was formed in the year 2000 in South Korea with members from different Korean nuclear organizations working on CANDU technology and subsequently membership was extended to global participants. Senior experts from the regulatory bodies, research establishments, operating organisations as well as designers and suppliers from around the world participate in the workshops of CANSAS. CANSAS-2015 was the 4th international workshop of CANSAS.

DAE has been organizing the international workshop on “New Horizons in Nuclear Reactor Thermal-Hydraulics and Safety (IW-NRTHS)” since 2007 with the purpose to discuss the recent developments and future challenges in various areas of nuclear reactor thermal hydraulics and safety. IW-NRTHS-2015 was the 5th workshop in this series. Since there is lot of

Chairman and Executive Director AERB addressing the August Gathering, CANSAS-2015 International Workshops held during December 8 to 11, 2015 at Mumbai

Prof. Devang V. Khakhar, Director IIT-Bombay and Chief Guest of the Function, visiting Exhibition Stalls

convergence in the areas of interest of IW-NRTHS and those of CANSAS-2015, these workshops were organized together with the objective of engaging a wider expertise and to discuss the generic issues of safety and sustainability in a more comprehensive manner.

The workshop, among other aspects, focused on areas related to R&D activities regarding PHWR safety, design innovations in PHWR fuel, severe accident management guidelines and challenges in safety regulation. There were detailed presentations on the various experiments being carried out across the globe, including India, in order to generate new data as well as support various models developed for simulating the behavior of reactor and its components.

10.1.2. Preparation for 7th Review Meeting of Convention on Nuclear Safety

India is committed to implement the provisions of the Convention on Nuclear Safety. Towards preparation of the upcoming 7th Review Meeting of the Convention on Nuclear Safety (CNS) in March 2017, an Organizational Meeting was held on October 15, 2015 at IAEA, Vienna. A four-member delegation represented India in the meeting. The Organizational Meeting was attended by the 65 Contracting Parties out of the total 77 Contracting Parties to the CNS. The meeting was primarily meant for deciding the provisional agenda of the forthcoming Review Meeting and to work out finer details for facilitating the peer review of the reports submitted by the various Contracting Parties.

10.2 BILATERAL COOPERATION

AERB has programme for bilateral cooperation with the regulatory bodies of other countries for sharing of experience in the field of regulation of nuclear activities for peaceful purposes and cooperation in nuclear and radiation safety matters. In this connection, AERB already has bilateral arrangements with the regulatory bodies of other countries namely, France, Russia, Romania, Ukraine, the United States of America and Finland. During the period, AERB has participated in a bilateral meeting with the Nuclear Regulatory Commission (NRC) of the United States of America and has entered into a bilateral arrangement with the Regulatory body of Canada (Canadian Nuclear Safety Commission). The details of the same are mentioned below.

10.2.1 Bilateral meeting between AERB and USNRC

As a part of nuclear safety cooperation programme between AERB and USNRC, a bilateral meeting was held during October 27-29, 2015 at AERB, Mumbai. A five-member delegation from USNRC participated in the meeting. The meeting was attended by NRC delegates and officials from AERB, BARC and NPCIL.

The safety experts from both the countries shared their experiences on regulatory practices and discussed various safety aspects regarding issues related to Safety Evaluation of Digital I&C (Instrumentation and Control) Systems, Containment Pressure Assessment for DEC (Design Extension Conditions) events, Equipment Qualification Program including under Design Extension Conditions, Severe Accident Management Guidelines Requirement and supporting Analysis, Operating experiences etc.

10.2.2 Deputation of AERB Officers to the USNRC

Under bilateral exchange of technical information and cooperation in nuclear safety matters with the US Nuclear Regulatory Commission (USNRC), AERB deputed two officers for a one year assignment to the USNRC. The purpose of this assignment was to share the information regarding functioning of the AERB and the NRC on the regulation of nuclear power plants. This assignment provided a unique opportunity for the officers to experience the functioning of the NRC with regard to regulation of operating NPPs and NPPs under construction by interacting with the staff of the NRC on daily basis & participating in their activities. The officers were associated with the work assignments of the USNRC office related to regulation of operating reactors and new reactors.

10.2.3 Safety Cooperation Arrangement with Canadian Regulatory Authority

In line with the Agreement between the Government of Canada and Government of the Republic of India for cooperation in the peaceful uses of nuclear energy (2010), AERB signed an arrangement for regulatory cooperation with Canadian Nuclear Safety Commission (the nuclear regulatory authority of Canada). The arrangement, amongst other things, provides for exchange and use of safety related information on any matter related to peaceful use of nuclear energy and radiation, exchange of personnel as temporary visits and training purposes. The agreement was signed on September 16, 2015 at Vienna, Austria by the Chairman, AERB (India) and President, CNSC (Canada) and is valid for a period of five years from the date of signing.

10.3 CONTRIBUTION IN INTERNATIONAL PEER REVIEW

On invitation extended by IAEA, two officials from AERB participated as members in the IAEA's Integrated Regulatory Review Service (IRRS) Missions to Armenia and Indonesia in June, 2015 and August, 2015 respectively. IRRS is a peer review service of IAEA which has been designed to strengthen and enhance the effectiveness of regulatory infrastructure of Member-States for nuclear, radiation, radioactive waste and transport safety and security of radioactive sources. IAEA has developed the IRRS to offer an integrated approach to the review of common aspects of any state's national, legal and governmental framework and regulatory infrastructure for safety. IRRS missions enable IAEA to carry out an objective comparison of the national regulatory infrastructure of a Member-State against IAEA Standards and Guidance and based on the review outcome the Mission provides the host country few recommendations and suggestions for improvement of existing legal and regulatory framework.

AERB plays an active role in strengthening the global safety regime and towards this contributes in various meetings, peer review missions and development/review of safety standards of IAEA. AERB also utilizes experience gained through these safety-cooperation activities towards further augmenting safety regulatory system within India.

10.4 PARTICIPATION IN THE ANNUAL CANDU SENIOR REGULATORS MEETING (CSRM), CANADA

The regulatory authorities of the seven countries which own and operate CANDU (Canada Deuterium Uranium) type Pressurized Heavy Water Reactors nuclear power plants, are member of CANDU Senior Regulators Group (CSRG) of IAEA. These countries namely, Argentina, Canada, China, India, Korea, Pakistan and Romania, meet annually in the CANDU Senior Regulators Meeting (CSRM) to discuss regulatory and operational issues for improving operational safety and enhancing regulatory effectiveness in CANDU countries. AERB officers represented India in the annual CANDU Senior Regulators Meeting held at Toronto, Canada during November 16-20, 2015. India took lead in the area of Fuel Channel Life Cycle Management (FCLM) and presented various developments carried out in the country. India provided the CSR Members a questionnaire on FCLM which would be filled by other member countries.

In wake of the developments being done with respect to Hydrogen management, a presentation on the analysis carried out with respect to hydrogen generation and distribution in the containment during accident scenarios was made. The newly developed Hydrogen Mitigation Studies (HYMIS) test facility, Hydrogen Recombiner Test Facility (HRTF) was discussed. India also made a presentation on “Emergency Phase to Transition Phase” – a concept introduced in the IAEA DS-474 (Arrangements for the Termination of a Nuclear or Radiological Emergency) and shared its experience with respect to the KAPS-2 event of pressure tube leak along with the post event activities.

10.5 PARTCIPATION IN IAEA & NEA ACTIVITIES

AERB has been actively involved with various international bodies for exchange of information and in co-operation in the field of regulation of nuclear activities for peaceful purposes. AERB experts have been actively participating in various activities of IAEA and have been contributing at various other international fora. AERB is the national coordinator for IAEA – International Nuclear Event Scale (INES) based reporting of events and IAEA/NEA –Incident Reporting System (IRS) and Fuel Incident Notification and Analysis System (FINAS).

AERB participates in various Technical and Consultants meetings organized by IAEA on a range of topics for NPPs, fuel cycle facilities, radiation facilities, transportation of radioactive materials etc. and illicit trafficking of radioactive materials. AERB has been participating in IAEA Coordinated Research Programme (IAEA-CRP) and NEA joint projects and information exchange programme.

10.5.1 Participation of AERB in the IAEA Activities

During the period, AERB officers participated and contributed in the following Technical and Consultants meetings organized by IAEA.

- Consultancy Meeting on Development of the International Reporting Systems (IRS)

- Meetings on Commission on Safety Standard (CSS)
- Meeting of the program committee of IAEA International conference on effective Nuclear Regulatory System
- Technical Meeting on Probabilistic Safety Assessment Framework for External Events
- Organizational meeting of the Convention on Nuclear Safety (CNS)
- Technical Meeting on "CANDU PAS"
- Consultancy Meeting regarding transforming experience into regulatory improvement.
- Consultancy Meeting for development of draft Technical Guidance for excising Nuclear Security Systems & Measures.
- Consultancy meeting for Development of Technical Guidance on Planning, Executing, Evaluating Exercises for Nuclear Security
- Technical Meeting of points of Contact for the Incident and Trafficking Database (ITDB)
- Consultancy Meeting on the Feasibility & Methodology for Development of the Cyber Design Basis Threat (DBT)
- Technical Meeting on the Draft Safety Guide on arrangements for the Termination of a Nuclear or Radiological Emergency
- Consultancy meeting on Development of an IAEA Publication on Safety Analysis & Documentation for Nuclear Fuel Cycle Facilities
- Convention on Nuclear Safety (CNS), officers turnover meeting and training of the officers
- Technical Meeting to review the IAEA Safety Guide on NPP Operational Safety
- Technical meeting on conducting cyber thereat assessment of nuclear facilities
- Technical meeting on Public Community Acceptability for Uranium Mining and Milling
- Technical meeting on Regulatory Oversight of Human & organizational factors
- Technical meeting on special security during life time of the nuclear facility
- Technical Meeting for development of Guidelines for Management of Disused Sources.
- Sub-Regional meeting on Nuclear Security Information Exchange & Co-ordination
- ICTP-IAEA Jointly organized School on Nuclear Energy management
- Extra ordinary meeting of the Transport Safety Standards Committee (TRANSSC) and SSR-6.

AERB, as a member, participated in the meetings of the fourth mandate activities of VVER Regulatory Forum PSA-WG and VVER Technical Expert Sub Group on Severe Accidents. AERB prepared a questionnaire to compare the member country practices on external event PSA. Based on the response received from different members, a report on the same is under preparation.

AERB officers also attended the following IAEA conferences/workshops/training programmes on various themes of interest,

- International Conference on the computer security in Nuclear World: Expert Discussion & Exchange.
- Workshop on Ageing Management of Fuel Cycle Facilities
- IAEA-ICTP organized workshop on Deterministic Safety Assessment
- Training workshop on development of severe accident management guidelines using IAEA's SAMG-D toolkit
- International Seminar on Challenges in the Licensing of the Nuclear Facilities w.r.t Nuclear Security
- International workshop on the International Physical Protection Advisory Services (IPPAS)
- IAEA-INES Training the Trainers workshop & INES Advisory Committee Annual Meeting
- Joint ICTP-IAEA School on Nuclear Energy Management
- SMiRT-23 Conference
- Training Course on Implementation of the IAEA Safety Guide on Radiation Protection & Safety in Medical uses of Ionizing Radiation.
- International Training course on Primitive and Protective Measures against incidence threats

- International workshop for Radiation Safety Reviewers in Integrated Regulatory Review Service Missions (IRRS).

10.5.2 Participation of AERB in the NEA Activities

AERB continued to coordinate the activities related to India's participation in the Nuclear Energy Agency (NEA) of OECD (Organisation for Economic Cooperation and Development) activities. During the period, experts from AERB were invited to contribute in the programs of NEA, including in the Committee on Nuclear Regulatory Activities (CNRA), Committee on the Safety of Nuclear Installations (CSNI) and Committee on Radiation Protection and Public Health (CRPPH) and their technical working groups. AERB experts participated in the working groups on Inspection Practices (WGIP), the Regulation of New Reactors (WGRNR), Operating Experience (WGOE) and Public Communication (WGPC).

AERB participates in the OECD/NEA joint project "Hydrogen Mitigation Experiments for Reactor Safety (HYMERES)" which is also supported by India. The project is aimed at improving the understanding of the hydrogen risk phenomenology in containment in order to enhance its modelling in support of safety assessment that will be performed for current and new nuclear power plants. Experiments are being carried out in PANDA and MISTRA test facilities by the operating agents. During the year, AERB had carried out the simulation and validation against various experiments that were carried out. The results and outcome of the assessment that was carried out during the year is presented in Section 8.5 of Chapter 8. AERB also carried out the preparatory activities for the up-coming NEA joint project titled 'Thermal-hydraulics, Hydrogen, Aerosols and Iodine Project' (THAI-3).

10.6 AERB'S ACTIVITIES AS MDEP MEMBER

The Multinational Design Evaluation Program (MDEP) is a multinational initiative to develop innovative approaches to leverage the resources and knowledge of the national regulatory authorities who are currently or will be tasked with the review of new reactor power plant designs.

AERB became a full member of the MDEP in April 2012. Among other things the focus of MDEP is to implement the MDEP products in order to facilitate the licensing of new reactors, including those being developed by the Generation IV International Forum. MDEP comprises 14 countries' nuclear regulatory authorities and is structured under 5 design-specific working groups and 3 issue-specific working groups which meet several times a year.

AERB is actively participating in the Policy Group (PG) and Steering Technical Committee (STC) apart from participation in one of the issue specific working groups 'Digital Instrumentation and Control Working Group (DICWG)', Code and Standards Working Group (CSWG) and Vendor Inspection Co-operation Working Group (VICWG). India is also participating in the activities of VVER working group and its subgroup working in the areas such as Reactor Pressure Vessel, severe accident and Fukushima Lesson Learnt.The technical guidance for MDEP is provided by Steering Technical Committee (STC), in which all the work products generated by various working groups are reviewed and approved.

During the period, AERB actively participated and contributed in MDEP Policy Group meeting and EPR Working Group Meeting (EPRWG).

Chapter 11

Human Resource Development & Infrastructure

The staff of AERB mainly consists of technical & scientific experts in different aspects of nuclear and radiation technology for meeting the requirement of consenting, safety review, research, inspections and analytical works. Besides AERB's own staff, required expertise is drawn from Technical support organisation, premier research centers, academic institutions and retired experts. AERB recognizes its human resource as a valuable asset in fulfilling its mandate. AERB gives paramount importance in maintaining a competent pool of human resources towards discharging its responsibilities and fulfilling its functions effectively and efficiently. Keeping this in view and as a long term strategy for ensuring high caliber human resources, AERB provides support and encourage its staff to pursue knowledge upgradation in topics relevant to regulatory functions and safety studies.

11.1 MANPOWER AUGMENTATION

AERB manpower is being augmented at various levels and through various channels in view of the expanding nuclear power programme and increasing number of radiation facilities in the country. This is being done through fresh recruitments, transfer of experienced personnel from operating plants and R&D institutes like BARC and IGCAR and induction of postgraduates through AERB Graduate Fellowship Scheme (AGFS) in IIT Bombay and IIT Madras.

Out of the total 130 new posts (103 Scientific & Technical and 27 Administrative/Accounts posts) sanctioned for the expansion of AERB under the XI Plan, 102 posts in Scientific & Technical and 27 posts in Administrative / Accounts / Auxilliary categories respectively have been filled. During the year, approval for additional manpower i.e. 115 Scientific & Technical posts under the XII Plan Expansion Project has been received from DAE. Recruitment action to fill up these posts will be taken up in due course.

Total sanctioned strength in AERB as on March 31, 2016 is 459 comprising of 389 scientific and technical and 70 supporting staff. Presently, in position strength is 326 comprising 267 scientific and technical & 59 supporting staff of Administrative/Accounts/ Auxiliary. In addition, there is a commitment for recruitment against the existing vacancies with IIT Bombay.

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

During the year 2015 (April 2015- March 2016), AERB recruited 04 officials through AGFS direct recruitment in Scientific Officer /C grade. Efforts have been made to fill up the two backlog vacancies in SC category in Group A post. Action has also initiated to fill the reserved vacancies (SC, ST, and OBC) in the various Scientific, technical and administrative grades. There are no backlog vacancies in Person with Disabilities Quota. Rosters are maintained as per the orders on the subject. The backlog vacancies are being worked out and periodic reports & returns are sent to DAE.

11.3 TRAINING

As a part of competence development, AERB continued to train its staff by organizing various training programmes, workshops, on-job training at nuclear facilities, refresher courses, technical talks, colloquia, participation in DAE's Advanced Training Institute (ATI) etc. Induction training is conducted through Orientation Course for Regulatory Process (OCRP) of AERB for the newly joined scientific/technical staff. The OCRP introduces the staff to organizational structure and functions of AERB, legal powers, policies, internal guidance and procedures of AERB.

AERB also imparts training on regulatory and safety aspects with respect to nuclear and radiation facilities to other organizations, on request.

11.3.1 Training Imparted for AERB Staff

11.3.1.1. Capacity Enhancement Programmes of Advanced Training Institute (ATI)

During the year, under the Capacity Enhancement Programme, 129 employees of AERB participated in relevant training programmes conducted by ATI.

11.3.1.2. Training based on Competency Mapping for Human Resource Development in AERB

Competency mapping analysis was carried out for the AERB Officers and based on the outcome, adequate training pogrammes have been identified. A training on 'Probabilistic Safety Analysis for Regulators- Nuclear Facilities' along with subsequent validation was conducted in November, 2015. Twenty three participants have participated in the training. Ten lectures were conducted as part of the training. Examination was also conducted on November 24, 2015 based on the lectures delivered in training.

A Refresher training course on topics related to 'Pressure Tube & Pressure Vessel' was designed for AERB officials from February 12- March 15, 2016. The training module comprising of eight lectures addressed conceptual aspects related to zirconium alloys and their relevance to Zr-2.5 Nb pressure tube and reactor pressure vessel right from atomic arrangements, mechanical properties, manufacturing, fracture mechanics, radiation damage etc. The training lectures were delivered by Dr. S. Chatterjee, an expert in the field of Metallurgy, Thirty four participants from AERB and NPCIL participated in the course.

AERB Officers participated in the training courses organized by the Indian Society for Non Destructive Testing (ISNT) Mumbai Chapter on 'NDT for Managers' (during Feb 15-19, 2016, attended by 16 AERB Officers) and 'Welding Inspection' (during March 14-30, 2016, attended by 15 AERB Officers). These training programmes addressed a wide range of Non Destructive Tests currently practiced including Ultrasonic Testing, Radiography testing, Leak Testing, Liquid Penetrant Testing, Magnetic Particle testing, Thermography, Eddy Current Testing, Visual testing, Acoustic Emission Testing, Welding Defects, Heat Treatment, Destructive Testing, Hydro and Pneumatic testing, Interpretation of weld radiographs, and details of ASME Sec-IX and salient parts of ASME Sec V and Sec VIII, acceptance criteria for the different NDT techniques, Demonstration on different NDT Techniques, with specific focus on radiography and welding gauges were arranged through various NDT institutes. Study material and participation certificate were given by ISNT to all the participants.

11.3.1.3 On-Job Training of AERB Staff

- Two senior officers from AERB were deputed to US Nuclear Regulatory Commission (NRC) for one year from February 7, 2015 to February 5, 2016. The interaction fostered mutual interaction and knowledge sharing in the area of regulation of nuclear power plants between AERB and the NRC. This assignment provided an opportunity for the officers to experience the functioning of NRC by interacting with the staff of the NRC on daily basis & participating in their activities.

- AERB, as a part of its staff training programme, deputed six Scientific Officers (having experience in PHWRs and Fast Reactor), along with three scientific assistants to Nuclear Training Center, at Kudankulam (KKNPP).The training included classroom as well as hands-on experience on plant simulator. All the candidates successful in their final assessment interview.

- Two Scientific Officers has successfully acquired Level-III (Control engineer) license for main plant operation of 540 MWe reactor.

- One Scientific officer is undergoing training at TAPS-3&4 to acquired Level-III (Control engineer) license for main plant operation.

- Two scientific officers have completed necessary training at PFBR as a pre-requisite for acquiring Level-III (Control engineer) license for main plant operation.

11.3.2 Training imparted for Others

11.3.2.1 Second Training Programme for officials of Bangladesh Nuclear Organisation

The second Fundamental Programme on Nuclear Energy (FCNE-2) was conducted by DAE for 20 Bangladesh officials during November 16-December 23, 2015. AERB officers provided the training on 'Regulatory Framework for Nuclear Power Plants and Fuel Cycle Facilities' module, including training materials for the entire course to each participant.

11.3.2.2 Training for Radiation Safety Cell/Agency

Training was conducted for the staff of Arunachal Pradesh Radiation Safety Agency during May 11-13, 2015.

11.4 AERB COLLOQUIA/LECTURES

Towards the aim of continual knowledge upgradation of its staff, AERB conducts technical talks/ colloquia on regular intervals. The topics are meticulously chosen in line with the mandate and functioning of AERB, covering latest scientific & technical developments worldwide in the field of nuclear and radiation industries, legal aspects, regulatory practices and aspects enhancing personal & interpersonal effectiveness etc. During the period following Colloquia/lectures were conducted at AERB,

- Technical talk on 'Approaches to Nuclear Regulations' by Shri R. B. Solanki, AERB.

- Colloquium on 'Safety Research Projects Funded by AERB' by project investigators of AERB's funded research projects.

- Invited talk on 'Financial Awareness' by Smt. Neelam Bhardwaj, ex-employee of SEBI and certified resource person for conducting financial awareness programs

- Invited talk on 'Dignity of Women in Humanity' by Smt. Nasreen Rustomfram, Chairperson of the Committee against Sexual Harassment (CASH) of TISS, Mumbai

11.5 KNOWLEDGE MANAGEMENT

11.5.1 Knowledge Portal

A 'Knowledge Portal' has been functional 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 included in the portal at regular intervals. National and international codes/ guides / manuals are also being included on the portal.

11.5.2 AERB Library

A well-equipped library is maintained in AERB. A total of 54 new publications have been added during the period and with this, the total collection of publications has gone up to 10,374. In addition, 20 Journals were 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 are also circulated regularly by email alerts.

11.6 DEVELOPMENT OF INFORMATION & TECHNOLOGY INFRASTRUCTURE

Development of Office Automation System

As a part of e-Governance activities, AERB is in the process of implementing a State-of-the-Art ERP Package (SAP) based Office Automation System (OAS), a web-based Information and Communication Technology (I&CT) application to computerize various functions in Administrative & Accounts Divisions along with some miscellaneous management functions like Committees Management, Meeting Management, Document Life Cycle Management, Movement & Status Tracking of Files, Tours & Air Ticket Booking, Utility Provisioning & Complaint Management, Purchase, Stores & Contract Management, RTI & Parliamentary Questions Database, Transport Management, Security Management, Time Attendance & Absentee Management etc. which are common to all divisions of AERB.

The system is having features like non redundant data entry, authenticated access to data, reliable information that can available instantly, role based work-flow implementation, automated planning/scheduling with alerts and effective tracking of status for tasks/cases. This totally integrated system has enabled faster processing & communication of data along with efficient analysis and dynamic query features. All the transactions are proposed to be on-line. In case, the signed papers/hardcopies are essential, users have been provided with a facility to upload the scanned copies of the same. This system is an attempt towards implementing paper-less office at AERB. The following modules of OAS have become operational:

- Time Attendance System & Finance.

- Leave Management

- Travel Management

- Purchase & Materials Management

- Meeting Management and consultants

- Employee Life-cycle Management

11.7 PROMOTION OF EXCELLENCE IN HUMAN RESOURCES

11.7.1 HIGHER QUALIFICATION

- Dr. Diptendu Das, SO(E), IPSD, AERB acquired Doctor of Philosophy in 'Liquid Emulsion Membranes for Recovery of Actinides from Dilute Aqueous Streams' from Indian Institute of Technology, Bombay.

- Dr.R.Bhattacharya, Outstanding Scientist, former Vice Chairman, AERB acquired Doctor of Philosophy in Faculty of Science & Humanities from Sathyabama University.

- Dr. Baburajan Kutty Parackal, SO (F), NSAD, AERB acquired Doctor of Philosophy in 'Investigations on CHF in Horizontal Tubes under LPLF Conditions from Indian Institute of Technology, Bombay.

11.7.2 AERB AWARDS FOR MERITOUS PERFORMANCE

AERB started its award scheme from the year 2012 to promote excellence among its staff and recognize outstanding achievements of those engaged in regulatory and associated research and development activities. AERB award scheme comprises of individual awards as well as group achievement awards. The categories of awards are: Young Scientific Officer Award, Outstanding Performance / Special Contribution Award, Leadership Award-1 (lower than SO/G), Leadership Award-2 (higher than SO/G), Meritorious Service Award and Group Achievement Award. In all these categories, awards for the year 2014-15 were distributed during the annual function of AERB on November 16, 2015. Dr. Ratan Kumar Sinha, DAE Homi Bhabha Chair Professor and Former Chairman, Atomic Energy Commission was invited as the Chief Guest of the function. Dr. R. K. Sinha, in his address to the AERB staff, delivered a talk on the topic, Nuclear Regulation in India and provided valuable insights on the current strength of AERB, Challenges Ahead and the Way Forward

Cat.1: Young Scientific Officer Award

1. Shri Rahul Porwal, SO/E, NPSD
2. Dr. S.P. Lakshmanan, SO/E, NSAD

Cat.2: Outstanding Performance/Special Contribution Award

1. Dr. Dinakrushna Mohapatra, SO/G, SRI
2. Dr. Ghanshyam Sahani, SO/F, RSD

Cat 3: Leadership Award

1. **Leadership Award-1**
   Shri Roshan Alayil Divakaran, SO/F, SSED

2. **Leadership Award-2**
   Shri P.R. Krishnamurthy, Director, OPSD

Cat.4: Meritorious Service Award

1. Smt. Mallika C. Nair, Sr. PS to Head, IPSD
2. Shri P. Narayanan, Sr. PS to CAO, AERB
3. Smt Radha Raghavan, PS (NS), OPSD
3. Shri Banwari D. Kajania, T/F, OPSD

Dr R.K.Sinha, Former Chairman, AEC, addressing the AERB staff during celebration of AERB's formation day

Cat 5: Group Achievement Award:

Group 1: (Regulatory Inspections of 700 MWe Projects)

- Shri A. D. Roshan, SO/F, SSED
- Shri S.K. Ghosh, SO/H+, NPSD
- Shri Ram Prakash Gupta, SO/G, NPSD
- Smt. K. Uma Sarma, SO/G, NPSD
- Shri Milind S. Mestry, SO/E, NPSD
- Shri Virendra Dhotre, SO/E, NPSD
- Shri Amar Kulkarni, SO/E, NPSD
- Dr. MayankVerma, SO/D, NPSD
- Shri Harpal Singh, SO/D, NPSD
- Shri Lakshman R. Surywanshi, TO/D, NPSD
- Shri T. Ramesh, SO/D, NPSD
- Shri Sourav Acharya, SO/F, SSED
- Shri M.K. Chakraborty, TO/E, SSED.

Group 2: (Design & Development of a user friendly centralized computerized document control/management system for tracking, assessment & report generation)

- Shri Neeraj Kumar, SO/E, OPSD
- Shri Ashish Jaiswal, SA/D, OPSD
- Shri Rahul Dhoke, SA/D, OPSD
- Shri Gopal Jee, SA/C, OPSD
- Shri Krishna Kumar, SA/C, OPSD
- Shri Nakkina Durga Prasad, SA/B, OPSD

Group 3:(Development of regulatory requirements for design of light water reactor based nuclear power plants in India)

- Shri K. Srivasista, Director, R&DD
- Shri S.K. Ghosh, SO/H+, NPSD
- Shri Jaharlal Koley, SO/G, OPSD
- Shri Dipto Bhattacharya, SO/F, OPSD

Group 4: Preparation & Analysis of IRRS-SARIS Questions

- Shri C.S. Varghese, SO/H+, NPSD
- Shri A.P. Garg, SO/H+, OPSD
- Shri S.K. Ghosh, SO/ H+, NPSD
- Shri J. Koley, SO/H, OPSD
- Smt Reeta Rani Malhotra, SO/G, C&RPD
- Shri R.U. Parmar, SO/G, OPSD
- Shri R.P. Gupta, SO/G, NPSD
- Shri A.D. Roshan, SO/F, SSED
- Shri S.C. Utkarsh, SO/G, NPSD
- Smt K. Uma Sarma, SO/G, NPSD
- Dr. P. Vijayan, SO/F, OPSD
- Shri Dipto Bhattacharya, SO/F, OPSD
- Shri Sekhar Bhattacharyya, SO/F, IPSD
- Shri S.K. Pawar, SO/F, OPSD
- Shri Ajai Pisharady, SO/F, SSED
- Shri A.K. Panda, SO/F, IPSD
- Shri Santosh K. Pradhan, SO/F, NSAD
- Shri Rajnish Kumar, SO/F, NPSD
- Kum. Swati Burewar, SO/F, NPSD
- Shri Animesh Biswas, SO/F, NPSD
- Shri Dhanesh Nagrale, SO/E, NSAD
- Shri Avinash Shrivastava, SO/E, OPSD
- Shri Anjit Kumar, SO/E, NPSD
- Shri Nishant K. Sangam, SO/E, OPSD
- Shri Soumen Sinha, SO/E, IPSD
- Shri Parikshat Bansal, SO/E, R&DD
- Shri Gour Mohan Behera, SO/E, C&RPD
- Shri Susheel Kumar, SO/E, C&RPD
- Smt Susmita Mukherjee, SO/D, SSED
- Smt Pinky Choudhary, TO/D, IPSD

Shri Rahul Porwal, NPSD received the 'Young Scientific Officer Award'

Dr. S.P.Lakshmanan, NSAD received the 'Young Scientific Officer Award

Dr.Dinakrushna Mopatra, SO/G, SRI, received the 'Outstanding Performance Award'

Dr. Ghanshyam Sahani, RSD received the 'Outstanding Performance Award'

Shri Roshan Alayil Divakaran, SSED, received the 'Leadership Award -1

Development of regulatory requirements for design of light water reactor based nuclear power plants in India

Smt. Mallika C. Nair, Sr. PS to Head, IPSD and Shri P. Narayanan, Sr. PS to CAO, AERB Received Meritorious Service Award'

Design & Development of a user friendly centralized computerized document control/management system for tracking, assessment & report generation)

Regulatory Inspections of 700 MWe Nuclear Power Projects

Preparation & Analysis of IRRS-SARIS Questions

11.8 WELFARE ACTIVITIES FOR AERB EMPLOYEES

11.8.1. AERB STAFF CLUB ACTIVITIES

AERB staff club conducts sports and cultural activities for the welfare of the staff and family members. A well-equipped physical fitness centre (gym) is being maintained by the AERB Staff Club efficiently for health benefit of its officials. During the year, sports tournaments were conducted for Cricket, Swimming, Brisk walk, Table Tennis, Badminton, Chess and Caroms successfully.

The AERB Annual Day was celebrated on December 12, 2015 in AERB Lawns. Around five hundred and forty persons consisting of AERB staff and their family members graced the occasion. The family members of AERB staff also participated in this annual cultural programme. The participants of the cultural programme were presented with mementos in appreciation of their talent. The prizes were distributed to the winners of sports tournaments-2015 and also to meritorious children of AERB employees who have secured above 90% in the academics.

11.8.2 INTERNATIONAL WOMEN'S DAY

International Women's day is celebrated every year at AERB with a large participation from its women's employees, where in debate and speeches are organised on the topics of common interest. This year, the women employees of AERB decided to do it in a different way and planned for a technical visit to the food irradiation facility at Navi Mumbai, arranged by Board of Radiation and Isotope Technology, Vashi. They visited various Radiation facilities at BRIT and got enlightened on various aspects of the application of radiation for the benefit of society.

11.8.3. VIGILANCE AWARENESS WEEK

AERB has celebrated the Vigilance Awareness Week during October 26-31, 2015. Apart from Pledge taking ceremony and Displaying Banners at prominent places, the following programmes were conducted during the week:

A Vigilance Quiz was conducted and many of our employees actively participated in it. A Debate on "Preventive Vigilance as a tool of Good Governance" was conducted by the students of Vivekananda Education Society, Chembur, Mumbai and the winners were honoured. A lecture was arranged on "Vigilance and Conduct Rules" addressing basic knowledge of CCS (Conduct) Rules and the necessity to follow the rules in Government Service.

Winners of Vigilance Quiz receiving prize from CAO, AERB

Winners of AERB Premier League 2015

AERB staff children performing dance programme on the eve of AERB's Annual Day

11.9 RETIREMENTS ON SUPERANNUATION

The following officials retired on superannuation during the period.

Sr. No.	Name	Design.	Date of retirement	Remarks
1	Shri. R D Salgaonkar	Technician 'G'	30/06/2015	Superannuation
2	Shri. S.S.Bajaj	Chairman	01/09/2015	Tenure of Completion and attaining the age of 70 yrs.
3	Dr. R. Bhattacharya OS,	Vice Chairman	31/10/2015	Superannuation
4	Shri. V. Mohan	SO (G)	31/10/2015	Superannuation

Chapter 12 Safety Promotional Activities

AERB organizes and/or participates in discussion meetings and other professional meets to deliberate on nuclear and radiation safety aspects and the system of regulatory regime followed by AERB and the basis of regulatory decision making process.AERB also organises safety promotional activities, the details of such events are given below.

12.1 DAE SAFETY AND OCCUPATIONAL HEALTH PROFESSIONALS MEET

AERB organizes and/or participates in discussion meetings and other professional meets to deliberate on nuclear and radiation safety aspects and the system of regulatory regime followed by AERB and the basis of regulatory decision making process. AERB also organises safety promotional activities, the details of such events are given below.

The 32nd Department of Atomic Energy (DAE) Safety & Occupational Health Professionals Meet was jointly organized by Atomic Energy Regulatory Board (AERB), Mumbai and Raja Ramanna Centre for Advanced Technology (RRCAT), Indore during October 05 - 07, 2015 at Indore. This Meet is organised annually with various themes on Industrial Safety and Occupational Health by AERB jointly with a Department of Atomic Energy (DAE) Units to promote and motivate Safety and Occupational Health in DAE. The themes for this year's three day Meet was “Safety in Evolving & Advanced Technological Applications” for Industrial Safety and “Positive Health Management” for Occupational Health Safety. Three hundred delegates from various DAE Units and DAE aided institutes participated in this Meet. Dr. A.E. Muthunayagam, Former Secretary, Ministry of Earth Sciences, Government of India delivered Dr. S.S. Ramaswamy Memorial Endowment Lecture on “Safety in Evolving & Advanced Technological Applications”. A Monograph on “Safety in Evolving & Advanced Technological Applications” & “Positive Health Management” was released during the Meet. A Technical Exhibition on Nuclear Technology, Industrial and Fire Safety Appliances, Laser Safety, Public Awareness & Safety and Regulatory Aspects was also organised during the Meet for the benefit of the participants and to encourage interactions between Industries and DAE Units.

32nd DAE Safety and Occupational Health Professionas Meet

(From left Shri S.M. Jalali,Head, Fire & Safety, RRCAT, Dr. R. Bhattacharya, Vice-Chairman, AERB, Dr. P.D. Gupta, Director, RRCAT, Shri S. A. Bhardwaj, Chairman, AERB, Dr. S.M.Oak, Head, SSLD, RRCAT, Dr. A.E.Muthunayagam, Former Secretary, Ministry of Earth Science, and Shri K. Ramprasad, Head, IPSD, AERB)

12.2 THEME MEETING ON 'RADIOLOGICAL CONSEQUENCES OF FUKUSHIMA ACCIDENT- AN UPDATE'

AERB organized a theme meeting on "Radiological Consequences of FUKUSHIMA Accident- an Update" at Niyamak Bhavan-A auditorium on January 12, 2016. The meet was organized to update AERB officials about Radiological consequences of Fukushima Accident and its effect on public and environment. Around 70 participants from various divisions of AERB had attended the meeting. Presentations were made on evacuation measures taken at Fukushima, radioactivity release in the environment, radiation exposure to the public, radiation protection aspects, heath consequences due to exposure to the public and for Non-human Biota. The meet brought out several issues relevant to improvements in radiation protection program and areas identified for future work.

12.3 THEME MEETING ON 'NEW DOSE LIMITS FOR EYE LENS-MEASUREMENT, MONITORING AND REGULATION'.

As per the existing AERB directive, occupational exposure of any workers shall be so controlled that the equivalent dose to the eye lens should not exceeds 150 mSv in a year. However, for occupational exposure in planned exposure situations, International Commission on Radiological Protection (ICRP) recommends an equivalent dose limit for the lens of the eye as 20 mSv in a year, averaged over defined period of 5 years, with no single year exceeding 50 mSv. AERB prescribes the occupational dose limits after a detailed review of dose limits as prescribed by ICRP and IAEA. In view of obtaining feedback from NPPs, AERB, BARC, IGCAR and other DAE units on the new guidelines for eye lens dose limits, a discussion meet was organised at Niyamak Bhawan (AERB), Mumbai on March 18, 2016. Around 80 participants from various units of DAE had attended the meeting. Eminent speakers from BARC, AERB, IGCAR and other organizations delivered the lectures on relevant topics such as biological effects of radiation on the lens of eyes, Dose measurement and regulation of eye lens dose, Monitoring of Eye Lens Dose- current development in India & International Practice, Radiation in interventional radiology, measurement of eye lens dose during medical application of radiation, relationship of cumulative low-level dose of ionizing radiation on human eye lens and occurrence of Cataract etc. After detailed discussion, based on the views expressed by speakers and feedback from participants it was concluded that "revised dose limits to the lens of eye" can be implemented in coming years.

Theme Meeting On 'New Dose Limits For Eye Lens - Measurement, Monitoring And Regulation' in progress
(L to R : Shri P.R.Krishnamurthy, Director, OPSD, AERB addressing the gathering, Shri S.K.Pawar, OPSD, Shri D. K.Shukla, ED, AERB and Dr. K.S. Pradeep Kumar, AD, HSE Group, BARC)

12.4 THEME MEETING ON 'QUALITY ASSURANCE DURING DESIGN AND MANUFACTURING OF SAFETY CRITICAL EQUIPMENT OF NUCLEAR POWER PLANT'

A Nuclear Power Project (NPP) in India is required to undergo an elaborate system of in-depth safety review during its various consenting stages; i.e. siting, design, construction, commissioning & operation. AERB follows a multi-tier safety review system and has specified safety requirements at every stage. The one aspect that features in all stages is the Quality Assurance Programme, which is an important component in ensuring safety. Quality Assurance Programme for different stages of nuclear power plants (NPPs) are reviewed by AERB as part of regulatory safety review process for obtaining consents at various stages. The AERB Safety Code on "Quality Assurance in Nuclear Power Plants" (AERB/NPP/SC/QA, Rev.1. February, 2009) provides the requirements to be complied by the utility for establishing and implementing quality assurance programme for assuring safety.

AERB organized a one day theme Meeting on 'Quality Assurance during Design and Manufacturing of Safety Critical Equipment of Nuclear Power Plants' with an objective to extend the regulatory oversight on QA aspects during design, procurement and manufacturing and formulate an action plan in this direction. The meet was organized on June 16, 2015 involving experts from the DAE organizations. Nine speakers with expertise on the subject of QA from AERB, BARC, IGCAR, NFC and NPCIL made presentations on different topics related to the theme of the meeting. While the presentation on current regulatory practices brought out areas needing enhancement of regulatory oversight, other presentations highlighted the experiences of QA experts during design and manufacturing at different DAE units. The Theme meeting was attended by 118 participants from AERB and other DAE Units.

Panel discussion in progress during theme meeting on
"Quality Assurance during Design and Manufacturing of Safety Critical Equipment of Nuclear Power Plant'


Chapter 13 Official Language Implementation

AERB has an established programme for the implementation of official language, Hindi. AERB is committed to the cause of Rajbhasha and have been continually improving in its endeavor of implementing Hindi in the regular official works, in accordance with official language provisions in the Constitution. In addition to the regular official works and various translations in to Hindi, AERB proactively initiates a series of activities throughout the year which include: publications, conducting training programmes, workshops, talks, annual competitions and divisional inspections for enhancement of use of Hindi in the divisional activities.

13.1 PUBLICATIONS IN HINDI

- Four AERB safety documents have been published in Hindi.
- Annual Report, AERB Newsletter and AERB Annual Bulletin have been published in Hindi and English, which are circulated to DAE units and various organizations of Govt. of India.
- Press releases were issued in Hindi and published in daily newspapers.
- Licenses, authorizations and inspections reports were issued in Hindi.
- During the period, a total of 5116 letters were sent in bilingual and 83 letters were sent exclusively in Hindi.

13.2 PROMOTIONAL ACTIVITIES FOR HINDI IMPLEMENTATION

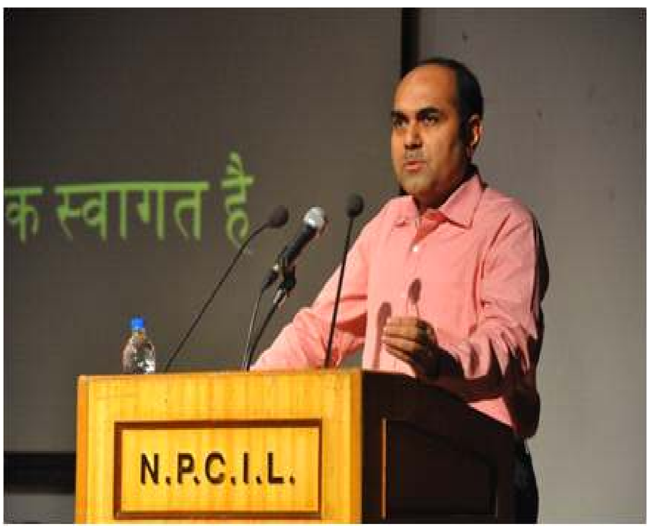
- Regular Meetings of Official Language Implementation Committee (OLIC) were organized to discuss on various issues related to effective use & implementation of Official Language in AERB. Recently in its meeting, it has been decided to re-start the publication of AERB Hindi Magazine "Niyamika" and accordingly, the process for publication of seventh issue (Year 2016) of "Niyamika" has been initiated.
- DAE Incentive Scheme for working in Hindi has been introduced and employees are actively participating in the scheme. Five employees were given award under this scheme.

13.3 HINDI TALKS/WORKSHOPS

- Four workshops were conducted (2 in Administrative Training Institute, 1 in AERB and 1 in BRIT, Vashi) on behalf of the Joint OLIC. The objective of workshops was to motivate the employees to take up Hindi in their day to day work and help them with the bottlenecks if any, in this regard. Fifteen officers of AERB attended these workshops.
- As a part of the Hindi Talk Series in AERB, one Hindi talk was organized during the period.
  - A talk by Shri Rajendra Singh (Magsaysay Award Winner), on "Jal Darshan & Samsamayik Sandarbh" on 23rd June, 2015. The talk was very informative and well appreciated by all.
- Hindi Day and the World Hindi Day were celebrated on September16, 2015 and January 12, 2016 respectively on behalf of the Joint Official Language Co-ordination Committee of the five DAE units, namely, AERB, DPS, HWB, DCSEM and BRIT.
  - On the Occasion of Hindi Day, Dr. Pankaj Chaturvedi from Tata Memorial Centre, Mumbai delivered a Hindi talk on "Cancer Par Vijay Kaise Payeen". The talk was very effective and useful.
  - On the occasion of World Hindi Day, a Kavi Sammelan was organized on 12th January 2016. The well-known stand-up comedian & poets Shri Dinesh Bawara, Shri Gaurav Sharma, Shri Baldev Trehan and Smt. Rana Tabbasum were invited in this programme.

Dignitaries on Dias during Hindi talk on "Jal Darshan & Samsamayik Sandarbh"

Shri Rajendra Singh (Magsaysay Award Winner) delivering a Hindi talk



Dr. Pankaj Chaturvedi, TMC delivering a Hindi talk

Stand-up comedian & poets Shri Dinesh Bawara, Shri Gaurav Sharma, Shri Baldev Trehan and Smt. Rana Tabbasum on Dias

13.4 HINDI COMPETITIONS

- Marking the Hindi Day Celebrations, a series of four Hindi competitions were held between 08th-15th of September, 2015 on behalf of Joint Official Language Coordination Committee at V.S. Bhavan, Mumbai. The closing ceremony was spectacularly designed with a gala of events.

- The prize distribution ceremony for the Hindi competitions conducted in AERB was held on 12th February, 2016. The highlight of the day was presentation of renowned Hindi songs on patriotic theme by Shri. Hemant Kumar Ametha, a well known singer of Rawatbhata, Kota, Rajasthan.

Shri Hemant Kumar Ametha, Singing a song during Hindi Prize Distribution Ceremony

Winners of Hindi Competitions receiving Prize from Chairman and Executive Director, AERB

Winners of Hindi Competitions receiving Prize from Chairman and Executive Director, AERB

Chapter 14 Technical Interaction With External Agencies

AERB believes in sharing its technical expertise with various Government Bodies, Universities etc. AERB officers are actively participating in preparation and revision of Bureau of Indian Standards (BIS) documents, Site Appraisal Committee of Ministry of Environment & Forest (MoEF), Working Groups on nuclear & radiological emergency plans constituted by National Disaster Management Authority (NDMA) etc. AERB encourages its technical divisions in providing project guidance to undergraduates and post graduate students from various Universities/Colleges.

Towards resolving generic issues related to radiation safety due to handling of radiation sources for various applications, AERB interacts with various ministries.

14.1 INTERACTION WITH OTHER AGENCIES

14.1.1 Bureau of Indian Standards (BIS)

Bureau of Indian Standards (BIS) the National Standards Body is involved in Standards Formulation apart from its other activities. During the period, AERB Officers were involved in review and revision of BIS documents and participated in the meetings conducted by BIS as Member of Committees/Sectional Committees of BIS as detailed below.

- In order to adopt a uniform approach for updating of all safety codes, BIS constituted a panel for revision of the following 13 chemical codes viz. IS 4644: 1968, IS 5208: 1969, IS 6270: 1971, IS 7415: 1974, IS 7444: 1974, IS 8388: 1977, IS 13440: 1992, IS 13441: 1992, IS 13442: 1992, IS 13447: 1992, IS 13910: 1993, IS 13911: 1993 & IS 13914:1993. One senior officer of AERB was involved in this activity and has carried out the revision of all the documents and submitted to BIS for necessary approval.

- As Panel member of BIS, one officer of AERB was involved in preparation of Indian Standard for Safe Practices for Storage and Handling of Nitrous Oxide, (CHD 07:P5) and revision of IS 4155:1966 Glossary of terms relating to chemical and radiation hazards and hazardous chemicals' (CHD07: P4).

- As members of BIS committees, AERB Officers participated in the meetings conducted by BIS and contributed in the review and discussions on development of BIS codes related to Cement and Concrete Sectional Committee and Earthquake Engineering Sectional Committee.

- **Collaborative study with Department of Hydrology, IIT Roorkee towards the preparation of state of the art report on flood hazard assessment of inland NPP sites**

The post Fukushima assessment carried out by AERB brought out the need for refinement of approaches followed for assessment of external events, particularly earthquake and floods as well as need for additional work in terms of assessment of extreme external events. The AERB guide for estimation of design basis flood for NPPs on inland sites was published in 1998. As part of revising this document, a collaborative study with Department of Hydrology, IIT Roorkee aimed to take up study of state of the art requirements on flood hazard assessment of inland NPP sites and identification of voids in current AERB requirements has been taken up. The work also takes into account related international guidelines such as from IAEA and NRC. Based on the work, a state of the art cum methodology document is expected to be generated on estimation of flooding in inland sites. The methodology so developed is expected to account for specific Indian meteorological and hydrological conditions, and also be able to cater to very low probability extreme events.

- Two JRFs were selected for the purpose of carrying out research in the area of PSA and reliability and High energy dosimetry at SRI under the aegis of MoU between AERB and Anna University. AERB Officers are also contributing as Doctoral committee members of Anna University and executive members of professional bodies at Kalpakkam.

14.1.2 Ministry of Environment & Forests (MoEF)

Dr. R. Bhattacharya, former Vice Chairman, AERB is a member of Site Appraisal Committee of MoEF for Nuclear Facilities & Strategic Facilities.

14.1.3 Interactions with Concerned Ministries for resolution of generic issues related to radiation safety

AERB is associated with various agencies in the process of ensuring radiation safety in radiation facilities and industries handling radiation sources. AERB is routinely interacting with various ministries for resolution of generic issues related to radiation safety due to handling of radiation sources for various applications. Towards this, AERB has interacted with various concerned ministries including,

- Ministry of Health and Family Welfare in connection with disposal of disused high activity radioactive sources in the Tele-therapy equipment.
- Ministry of Home Affairs and Ministry of Shipping in connection with installation of portal monitors to curb illicit trafficking of radioactive material.
- Ministry of Steel in connection with instances of steel and metal (low-level radioactivity) contamination.
- Directorate General for Foreign Trade in connection with establishment of requirement of AERB authorization for import of x-ray equipment into the country.

14.1.4 Participation in the Aerosol Experimental Program at National Aerosol Facility, IIT-Kanpur

In a severe accident condition, the release of radioactive materials takes place mostly in the form of aerosol, in addition to some volatile species. These released aerosols from core region find their path into the primary heat transport system (PHT) and subsequently into the containment, which is the final barrier controlling their release into the environment. The transport and deposition of fission products and aerosols within the PHT is a transient convection problem of a multi-component, multiphase mixture with simultaneous heat and mass transfer, chemical reaction and aerosol kinetics. In a collaborative effort to study the various phenomena involved, a National Aerosol Facility (NAF) is being set-up at Indian Institute of Technology (IIT), with association of BRNS, BARC and IIT-Kanpur. The proposed experiments will simulate the aerosol behavior studies in feeder pipelines of Pressurized Heavy Water Reactor (PHWR) in severe accident conditions. The aerosol experiments that are to be carried out will also be used to validate various computer codes. AERB coordinates input specification team comprising BARC, NPCIL and AERB for test matrix formulation. AERB participated in the computer simulation exercises using thermal hydraulics code RELAP, accident source term analysis code ASTEC and in-core radionuclides inventory calculation using ORIGEN. Experimental results generated by the NAF will be used to validate the available computer codes in AERB.

14.2 PROJECT GUIDANCE

Technical divisions of AERB provided project guidance to undergraduate engineering students as well as M. Tech students. In addition, Ph.D students registered from AERB are being guided at the respective divisions. During the year officers of AERB have guided research scholars and students on the following projects.

- Guidance for young engineering students were provided by NSAD, AERB for three students from BITS Pilani w.r.t. their projects on "Accident analysis (Simultaneous occurrence of station blackout and Loss of coolant accident) of VVER 1000 using ASTEC", "Nuclear Reactor Stability Analysis (Frequency Domain)" and "Nuclear Reactor Stability Analysis (Time Domain)".
- One M.Tech Engineering student from MGM's Jawaharlal Nehru Engineering College, Aurangabad received guidance on project related to 'CFD Simulation for radiochemical dispersion of probabilistic releases from nuclear facility'.
- Development and application of probabilistic safety assessment methodologies for estimating risk from nuclear power plants (on-going Ph.D. program).

Technical guidance provided by Safety Research Division of AERB at Kalpakkam,

- Numerical study of water hammer transients in Parallel pump feed water systems (M.S. program).
- Numerical and experimental investigations on hydrogen mitigation (On-going Ph.D program).
- Two final year M.Sc Chemistry students were given technical guidance as part of their academic

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LIST OF ABBREVIATIONS

AAFR	:	Additional Away From Reactor
ACOH	:	Advisory Committee on Occupational Health
ACPSR	:	Advisory Committee for Project Safety Review
ACPSR-FCF	:	Advisory Committee for Project Safety Review-Fuel Cycle Facilities
ACRDCSE	:	Advisory Committee for Regulatory Documents on Civil and Structural Engineering
ACSD-FCF	:	Advisory Committee on Safety Documents related to Fuel Cycle Facilities
ADS	:	Automatic Depressurization System
AERB	:	Atomic Energy Regulatory Board
AGFS	:	AERB Graduate Fellowship Scheme
AHX	:	Air Heat Exchanger
AIIMS	:	All India Institute of Medical Sciences
ALARA	:	As Low As Reasonably Achievable
ALPAS	:	Automatic Liquid Poison Addition System
AMD	:	Atomic Minerals Directorate for Exploration and Research
AMP	:	Ageing Management Programs
AOO	:	Anticipated Operational Occurrences
AOT	:	AERB Observers Team
API	:	American Petroleum Institute
ARA	:	Application for Renewal of Authorisation
ARL	:	Application for Renewal of License
ARM	:	Advanced Reference Material
ARMS	:	Automatic Radiation Monitoring System
ASDV	:	Atmospheric Steam Discharge Valve
ASEM	:	Asia Europe Meeting
BAR	:	Burnable Absorb Rod
BARC	:	Bhabha Atomic Research Center
BCD	:	Bleed Condenser
BDBE	:	Beyond Design Basis Event
BEXD	:	Boron Enrichment Exchange Distillation
BEP	:	Boron Enrichment Plant
BEPU	:	Best Estimate Plus Uncertainty
BIS	:	Bureau of Indian Standards
BITS	:	Birla Institute of Technical Sciences
BOPS	:	Blow Out Panels
BRIT	:	Board of Radiation & Isotope Technology
BSD	:	Biennial Shutdown
BSM	:	Beach Sand Minerals
BSM-NORMSC	:	Beach Sand Minerals & Naturally Occurring Radioactive Materials Safety Committee
CANDU	:	Canada Deuterium Uranium
CANSAS	:	CANDU Safety Association for Sustainability
CCF	:	Common Cause Failures
CDF	:	Core Damage Frequency
CESC	:	Civil Engineering Safety Committee
CESCOP	:	Civil Engineering Safety Committee For Operating Plants
CFD	:	Computational Fluid Dynamics
CFTF	:	Compartment Fire Test Facility
CFVS	:	Containment Filtered Venting System
CHF	:	Critical Heat Flux
CNCAN	:	National Commission for Nuclear Activities Control
CNRA	:	Committee on Nuclear Regulatory Activities
CNS	:	Convention on Nuclear Safety
CORAL	:	Compact Reprocessing of Advanced Fuels in Lead Cell
CPS-AR	:	Control Protection System-Absorber Rod

CPV	:	Cooling Pool Vessel
C&RPD	:	Communication & Reactor Physics Division
CS	:	Codes and Standards
CSNI	:	Committee on Safety of Nuclear Installations
CSP	:	Core Sub-Assembly Plant
CSR	:	Control and Safety Rods
CSRDM	:	Control and Safety Rod Drive Mechanism
CSRP	:	Committee for Safety Research Programmes
CSS	:	Containment Spray System/ Committee on Safety Standards
CT	:	Calandria Tubes
CV	:	Calandria Vault
CWMF	:	Centralized Waste Management Facility
DAE	:	Department of Atomic Energy
DAE-ALSC		DAE-Accelerator and Laser Safety Committee
DBA	:	Design Basis Accident
DBFL	:	Design Basis Flood Level
DBGM	:	Design Basis Ground Motion
DBR	:	Design Basis Reports
DCH	:	Direct Containment Heating
DCSEM	:	Directorate of Construction, Services & Estate Management
DCVs	:	Double Check Valves
DFAs	:	Dummy Fuel Assemblies
DFRP	:	Demonstration Fast Reactor Fuel Reprocessing Plant
DG	:	Diesel Generator
DGFT	:	Director General of Foreign Trade
DGOP	:	Director General's Office of Policy
DHR	:	Decay Heat Removal
DIC	:	Digital Image Correlation/Digital Instrumentation and Control
DICWG	:	Digital Instrumentation & Control Working Group
DILs	:	Derived Intervention Levels
DND	:	Delayed Neutron Detector
DPPs	:	Draft Preparation Profile
DPS	:	Directorate of Purchase and Stores
DRP	:	Diploma in Radiological Physics
DRS	:	Directorate of Radiation Safety
DSL	:	Design Safety Limit
DSR	:	Diverse Safety Rod
DSRC	:	Design Safety Review Committee
DSRC-DP		Design Safety Review Committee for Diversified Projects
DSRC-UEP	:	Design Safety Review Committee for Uranium Extraction Projects
DSS	:	Decision Support System
EALs	:	Emergency Action Levels
ECCS	:	Emergency Core Cooling System
ECD	:	Electron Capture Detector
ECIL	:	Electronics Corporation of India Ltd.
ECIL-SC	:	ECIL Safety Committee
EE-PSA	:	External Event Probabilistic Safety Analysis
EFPSA	:	External flooding PSA
EIA	:	Environment Impact Assessment
EIA-NRS	:	Environmental Impact Assessment - in respect of Nuclear & Radiological Safety
ELCB	:	Earth Leakage Circuit Breaker
eLORA	:	e Licensing of Radiation Applications
EMCCR	:	En-Mass Coolant Channel Replacement
EMFR	:	En-Mass Feeder Replacement
EMI	:	Electromagnetic Interference
EMTR	:	Emergency Transfer
EP	:	Embedded Part
EP	:	Emergency Protection
EPP	:	Emergency Preparedness Plan
EPR	:	Evolutionary Pressurized Water Reactor
EPRWG	:	Evolutionary Pressurized Reactor Working Group
EQ	:	Equipment/Environment Qualification
ERM	:	Environmental Radiation Monitor

ERP	:	Entity Resource Planning
ERRC	:	Eastern Regional Regulatory Centre
ESBO	:	Extended Station Blackout
ESFs	:	Engineered Safety Features
ESLs	:	Environmental Survey laboratories
F.R	:	Frequency Rate
FA	:	Fuel Assembly
FAAC	:	Fatal Accident Assessment Committee
FAC	:	First Approach to Criticality
FAR	:	Fatal Accident Rates
FAs	:	Fuel Assemblies
FBTR	:	Fast Breeder Test Reactor
FCE	:	Front-End Fuel Cycle Facilities
FDS	:	Fire Dynamic Simulator
FEA	:	Finite Element Analysis
FEL	:	Free Electron Laser
FEL-LINAC	:	Free Electron Laser-Linear Accelerator
FEM	:	Finite Element Method
FFP	:	Fuel Fabrication Plant
FMS	:	Flux Mapping System
FMSA	:	Fuelling Machine Service Area
FOAK	:	First of a Kind
FP	:	Full power
FPC	:	First Pour of Concrete
FPNG	:	Fission Product Noble Gases
FRFCF	:	Fast Reactor Fuel Cycle Facility
FRP	:	Fuel Reprocessing Plant
FSA	:	Fuel Subassembly
FSAR	:	Final Safety Analysis Report
GHAVP	:	Gorakhpur Haryana Anu Vidyut Pariyojana
GIC	:	Gamma Irradiation Chamber
GT	:	Generator Transformer
HAZOP	:	Hazard and Operability
HEF	:	Head End Facility
HBNI	:	Homi Bhabha National Institute
HDC	:	High Density Concrete
HDR	:	High Dose Rate
HDS	:	Hydrogen Distribution Simulator
HDT	:	High Dose Therapy
HEF	:	Head End Facility
HEWAC	:	Heavy Water Clean-Up
HPC	:	High Pressure Containment
HPECCS		High Pressure Emergency Core Cooling System
HPME	:	High Pressure Melt Ejection
HPRE	:	High Purity Rare Earths
HRR	:	Heat Release Rate
HSEG	:	Health Safety and Environment Group
HWL	:	High Water Line
HWP	:	Heavy Water Plants
HWP-SC	:	Heavy Water Plants Safety Committee
HYMERES	:	Hydrogen Mitigation Experiments for Reactor Safety
HZP	:	Hot Zero Power
I&CT	:	Information and Communication Technology
I&C	:	Instrumentation and Control
IAEA	:	International Atomic Energy Agency
IC	:	Inner Containment
ICSA	:	Instrumented Core Sub-assembly
ICSD	:	Ionization Chamber Smoke Detector
ICSP	:	International Collaborative Standard Problem
IDCT	:	Induced Draught Cooling Tower
IFL	:	Initial Fuel Loading
IFSB	:	Interim Fuel Storage Building
IGALL	:	International Generic Ageing Lessons Learned
IGCAR	:	Indira Gandhi Center for Atomic Research
IHRGs	:	In-House Review Groups
IICT	:	Indian Institute of Chemical Technology
IIT	:	Indian Institute of Technology
IL	:	Investigation Levels

ILRT : Integrated Leak Rate Test

IMS : Ion Mobility Spectrometer

INAE : Indian National Academy of Engineering

INES : International Nuclear and Radiological Event Scale

IOT : Intermediate Oil Tank

IPSD : Industrial Plants Safety Division

IR : Intermediate Range / Infra Red / Incidence Rates

IREL : Indian Rare Earths Limited

IRGD : Industrial Radiation Gauging Device

IRIS : Improving the Robustness assessments methodologies for structures Impacted by missiles

IRRS : Integerated Regulatory Review Service

IRS : Incident Reporting System

ISI : In-Service Inspection

ISO : International Organization for Standardization

ISSC : International Seismic Safety Center

IT : Information Technology

JHA : Job Hazard Analysis

JNPP : Jaitapur Nuclear Power Project

KAPP : Kakrapar Atomic Power Project

KGS : Kaiga Nuclear Power Station

KKNPP : Kudankulam Nuclear Power Project

KNS : Korea Nuclear Society

KRSC : KGS 1 to 4 and RAPS 3 to 6 Safety Committee

LBE : Lead Bismuth Eutectic

LBLOCA : Large Break Loss of Coolant Accident

LHGR : Linear Heat Generating Rate

LHS : Latin Hypercube Sampling

LLW : Low Level Wastes

LMFBR : Liquid Metal Cooled Fast Breeder Reactor

LMODC : Loss of Moderator Cooling

LOECC : Loss of Emergency Core Cooling

LOCA : Loss of Coolant Accident

LPECCS : Low Pressure Emergency Core Cooling System

LPLF : Low Power Low Flow

LRP : Large Rotating Plug

LVDT : Linear Variable Differential Transformer

LZC : Liquid Zone Control

MA : Minor Actinides

MAL : Main Airlock

MAPS : Madras Atomic Power Station

MBR : Mass Burning Rate

MC : Monte Carlo

MCL : Minimum Controlled Power Level

MCR : Main Control Room

MDEP : Multi National Design Evaluation Program

MISTRA : Mitigation and Stratification

MLPAS : Moderator Liquid Poison Addition System

MMPA : Modified Multimode Push over Analysis

MoEF : Ministry of Environment and Forests

MoPP : Monazite Processing Plant

MoU : Memorandum of Understanding

MSP : Mineral Separation Plants

NAPS : Narora Atomic Power Station

NARAC : National Atmospheric Release Advisory Centre

NC : Non Conformance

NC : Natural Circulation

NDMA : National Disaster Management Authority

NEA : Nuclear Energy Agency

NEI : Nuclear Energy Institute

NEMIS : Nuclear Emergency Management Information System

NFAR : Non-Fatal Accident Rates

NFC : Nuclear Fuel Complex

NFME : Neutron Flux Monitoring Equipment

NGADU : Nuclear Grade Ammonium Di-Uranate
NISST : National Institute of Secondary Steel Technology
NKSC : NAPS-KAPS Safety Committee
NMA : Near Miss Accidents
NOC : Normal Operating Condition
NORM : Naturally Occurring Radioactive Materials
NPCIL : Nuclear Power Corporation of India Limited
NPPs : Nuclear Power Plants
NPSD : Nuclear Projects Safety Division
NREMC : Nuclear and Radiological Emergency Monitoring Cell
NRRC : Northern Regional Regulatory Centre
NSAD : Nuclear Safety Analysis Division
NSDF : Near Surface Disposal Facility
NSGC : Nuclear Security Guidance Committee
NUSSC : Nuclear Safety Standards Safety Committee
OAS : Office Automation System
OBE : Operating Basis Earthquake
OCRP : Orientation Course for Regulatory Processes
ODC : Over Dimension Consignment
ODE : Ordinary Differential Equations
OECD : Organisation for Economic cooperation and Development
OEIC : Over Exposure Investigation Committee
OILs : Operational Intervention Levels
OJT : On the Job Training
OLBS : On-Line Boron Measurement System
OLIC : Official Language Implementation Committee
OPRD : Over Pressure Rupture Device
OPSD : Operating Plants Safety Division
OREDA : Offshore Reliability Handbook
OSART : Operational Safety Review Team
OSCOM : Orissa Sand Complex
OSEE : Off-Site Emergency Exercise
PAR : Passive Autocatalytic Recombiners
PCPs : Primary Coolant Pumps
PCT : Peak Clad Temperature
PDHRS : Passive Decay Heat Removal System
PDSC : Project Design Safety Committee
PDU : Potassium Di-Uranate
PEE : Plant Emergency Exercises
PET : Positron Emission Tomography
PFBR : Prototype Fast Breeder Reactor
PG : Policy Group
PGA : Peak Ground Acceleration
PHRS : Passive Heat Removal System
PHT : Primary Heat Transport
PHWRs : Pressurized Heavy Water Reactors
PLCs : Programmable Logics Controllers
PORV : Pilot Operated Relief Valves
PPE : Personal Protective Equipment
PPF : Process Plant Facility
PS : Power Supply
PSI : Pre-Service Inspection
PSA : Probabilistic Safety Assessment
PSAR : Preliminary Safety Analysis Report
PSD : Partial Shutdown
PSE : Physical Startup Equipment
PSI : Pre-Service Inspection
PSR : Periodic Safety Review
PT : Pressure Tube
PWR : Pressurized Water Reactor
QA : Quality Assurance
QMS : Quality Management System
R&DD : Resources & Documentation Division
R&D : Research and Development
RAL : Remote After Loading
RAPP : Rajasthan Atomic Power Project
RAPS : Rajasthan Atomic Power Station

RASSC	:	Radiation Safety Standard Committee
RBCW	:	Reactor Building Cooling Water
RCA	:	Root Cause Analysis
RCP	:	Reactor Coolant Pump
RCS	:	Reactor Coolant System
RDRC	:	Radioactive Waste Disposal Committee
RFF	:	Resin Fixation facility
RIA	:	Radiological Impact Assessment
RIH	:	Reactor Inlet Header
RITs	:	Reactivity Insertion Transients
RIs	:	Regulatory Inspections
RLA	:	Residual Life Assessment
RMSC	:	RAPS-MAPS Safety Committee
ROpER	:	Regulator Operating Experience Review
ROH	:	Reactor Outlet Header
RP&AD	:	Radiation Protection and Advisory Division
RPF	:	Radiation Processing Facility
RPV	:	Reactor Pressure Vessel
RRCAT	:	Raja Ramanna Centre for Advanced Technology
RRS	:	Reactor Regulatory System
RSA	:	Radiation Safety Agency
RSD	:	Radiological Safety Division
RSM	:	Radiation Survey Meters
RSO	:	Radiological Safety Officer
RTC	:	Regional Training Course
RTI	:	Right to Information Act
RUP	:	Reprocessed Uranium Oxide Plant
SA	:	Severe Accident
SACNUM	:	Safety Committee for Nuclear Medicine
SAMG	:	Severe Accident Analysis & Management Guideline
SAP	:	System and Application Programs
SARCAR	:	Safety Review Committee for Application of Radiation
SARCOP	:	Safety Review Committee for Operating Plants
SARIS	:	Self Assessment of Regulatory Infrastructure for Safety
SBO	:	Station Black Out
SC	:	Safety Codes
SCCI&CS	:	Standing committee on Control for Instrumentation & Computer Based Systems
SC-RP	:	SARCOP Standing Committee-Reactor Physics
SCR	:	Supplementary Control Room
SCDF	:	Site Core Damage Frequency
SDU	:	Sodium Di-Uranate
SEC	:	Site Evaluation Committee
SEC-JNPP	:	Site Evaluation Committee for JNPP
SEE	:	Site Emergency Exercise
SERs	:	Significant Event Reports
SG	:	Safety Guides
SG-DHRS	:	Safety Grade Decay Heat Removal System
SGs	:	Specialist Groups
SHC	:	Super Heavy Concrete
SM	:	Safety Manuals
SMS	:	Short Message Service
SNAS	:	Secured Network Access System
SOHPM	:	Safety & Occupational Health Professionals Meet
SOP	:	Standard Operating Procedure
SPECT	:	Single Photon Emission Computed Tomography
SPND	:	Self Powered Neutron Detectors
SR	:	Source Range
SR	:	Severity Rate
SRI	:	Safety Research Institute
SRP	:	Small Rotating Plug
SRRC	:	Southern Regional Regulatory Centre
SRS	:	Software Requirement Specification
SS	:	Safety Standards
SS	:	Stainless Steel

SSC	:	Structures, Systems and Components
SSDL	:	Secondary Standard Dosimetry Laboratory
SSE	:	Safe Shutdown Earthquake
SSED	:	Siting & Structural Engineering Division
SSL	:	Secure Socket Layer
SST	:	Sea Surface Temperature
SSW	:	Salt Service Water
STC	:	Steering Technical Committee
STQC	:	Standardisation Testing and Quality Certification
TAPS	:	Tarapur Atomic Power Station
TBP	:	Tri Butyl Phosphate
TD	:	Technical Documents
TDP	:	Technology Demonstration Plant
TECDOC	:	Technical Document
TESGs	:	Technical Expert Sub-Groups
TFs	:	Task Forces
TG	:	Turbine-Generator
THRUST	:	Thorium Retrieval Uranium Recovery and Re-storage
TLAA	:	Time Limited Ageing Assessment
TLD	:	Thermo Luminescence Dosimeter
TPW	:	Tsunami Protection Wall
TRANSSC	:	Transport Safety Standard Committee
TRIKIN	:	TRIangular Meshes Based KINetics
UASC	:	UCIL & AMD Safety Comitee
UBDS	:	Ultrasonic Ball Detection System
UCIL	:	Uranium Corporation of India Limited
ULC	:	Ultimate Load Capacity
URP	:	Uranium Recovery Plant
USC	:	Unit Safety Committees
USNRC	:	United States Nuclear Regulatory Commission
VECC	:	Variable Energy Cyclotron Centre
VIC	:	Vendor Inspection Co-operation
VICWG	:	Vendor Inspection Co-operation Working Group
VPN	:	Virtual Private Network
VRSC	:	VECC RRCAT Safety Committee
VSPP	:	Versatile Solvent Production Plant
VTF	:	Value Test Facility
VVER	:	Vodo-Vodyanoi Energetichesky Reactor
WASSC	:	Waste Safety Standard Committee
WGs	:	Working Groups
WGPC	:	Working Group on Public Communication
WMD	:	Waste Management Division
WMP	:	Waste Management Plant
WR	:	Working Range
ZC	:	Zirconium Complex

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 Fukushima NPP, Japan, 2011
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 measur es • Severe damage to r eactor core/Several Deaths from radiation. • Release of large qualities of radioactive material within an installation with a high probability of significant public e xposure. This could arise from a major criticality accident or fir e	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 Mayapuri Incident, India, 2010
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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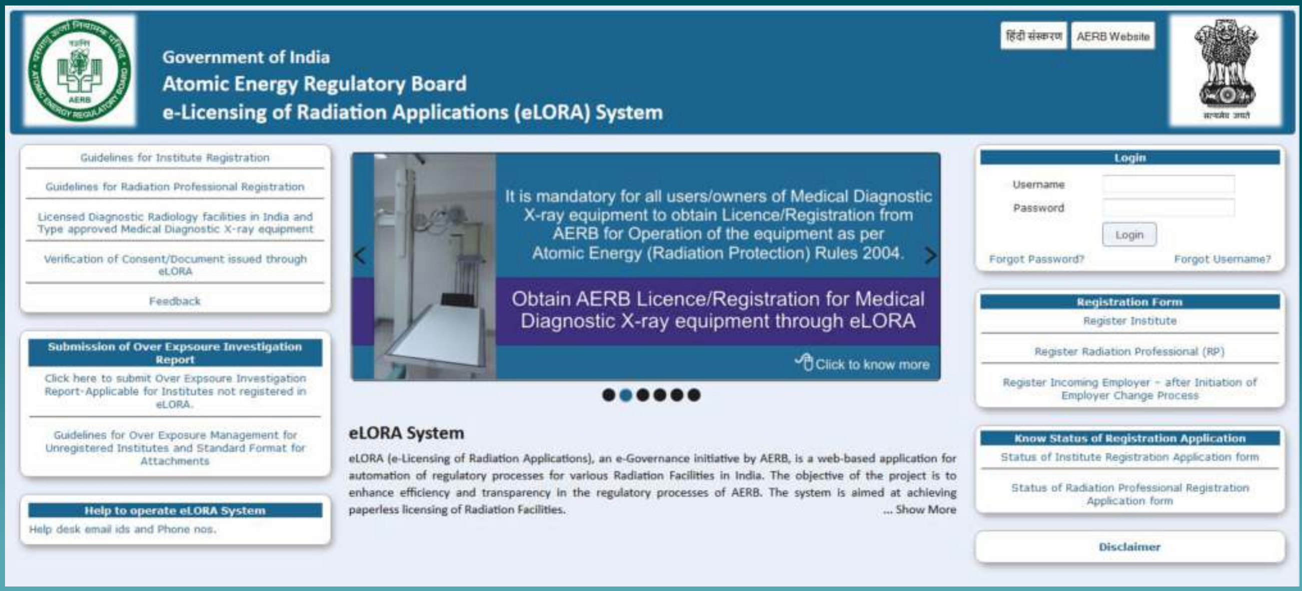

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