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ANNUAL REPORT 2023

ATOMIC ENERGY REGULATORY BOARD

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. AERB's headquarter is at Mumbai.

The Board comprises of six members consisting of Chairman, AERB, Executive Director, AERB and four eminent external experts from various disciplines relevant to the mandate of the Board. The Board is responsible to Atomic Energy Commission (AEC). The Board is assisted in execution of its mandate by a Secretary who is an employee of the Secretariat. The Secretariat of AERB has its office at Mumbai (headquarter), and Regional Regulatory Centres at Chennai, Kolkata and New Delhi and a Safety Research Institute at Kalpakkam.

AERB carries out its functions through its qualified workforce at Secretariat under the guidance of the Board. The Secretariat comprises of technical divisions and a Safety Research Institute (SRI) catering to the safety regulation of nuclear and radiation facilities all over the country. Regional Regulatory Centres (RRCs) of AERB carry out regular surveillance of the radiation facilities in eastern, southern and northern zones. Executive Director and Heads of Directorates / Divisions constitute the Executive Committee, which meets periodically and takes decisions on important matters related to the functioning of AERB. The Secretariat is assisted in its safety review activities by review committees viz. Apex level safety committees include Safety Review Committee for Operating Plants (SARCOP), Advisory Committees for Project Safety Review (ACPSRs) and Safety Review Committee for Applications of Radiation (SARCAR). In addition, there are advisory committees, viz. Advisory Committee on Nuclear and Radiological Safety (ACNRS) and Advisory Committee on Security (ACS). Recommendations of these committees are considered by the Secretariat for regulatory decision making.

The administrative and regulatory mechanisms are in place to ensure multi-tier review of safety matters by experts in the relevant fields available nationwide. These experts are chosen from reputed academic institutions, R&D organisations, industries and governmental agencies.

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

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

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GOVERNMENT OF INDIA

ATOMIC ENERGY REGULATORY BOARD

ANNUAL REPORT - 2023

NIYAMAK BHAVAN, ANUSHAKTI NAGAR
MUMBAI-400 094

Website: www.aerb.gov.in

FUNCTIONS OF ATOMIC ENERGY REGULATORY BOARD

- Develop safety policies in the areas of nuclear, radiation and industrial safety for facilities under its purview.
- Develop Safety Codes, Guides and Manuals for siting, design, construction, commissioning, operation and decommissioning for nuclear and radiation facilities.
- Grant consents/licenses for siting, construction, commissioning, operation and decommissioning, after an appropriate safety review and assessment 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 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 organisations abroad regarding safety matters.
- Promote research and development in the areas of safety.
- Review nuclear, radiological and industrial safety aspects in nuclear facilities under its purview.
- Review 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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MISSION AND VISION OF AERB

MISSION

The mission of AERB is to ensure the use of ionising radiation and nuclear energy in India does not cause undue risk to the health of people and the environment.

VISION

The vision of AERB is to be a knowledge organisation of high international standards with state-of-the-art scientific capabilities and to maintain high level of professionalism, credibility, transparency and accountability in the domain of its regulatory responsibilities.

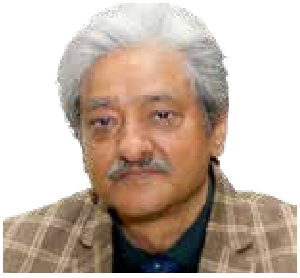
ORGANISATIONAL STRATEGIES

The organisational strategy is developed around AERB's organisational policies, core values, and functional mandate and is as follows:

- Developing an organisational structure commensurate with the Integrated Management System.
- Ensuring strong organisational capability by embedding safety culture and leadership in AERB staff.
- Building and maintaining staff competence and providing them with adequate resources for performing their functions and discharging their responsibilities.
- Conducting and promoting state-of-the- art safety research in line with international benchmarks for use in development of regulations and regulatory decision making.
- Establishing means of management and preservation of the knowledge of the organisation like periodic trainings, special trainings, seminars, etc.
- Using graded approach, based on risk associated and complexity of the facility or activity being regulated, as applicable, while discharging its mandate which include resource utilization commensurate with the associated risks.
- Adopting a balanced approach between prescriptive, performance based and process based regulation.
- Implementing regulatory processes in a manner that does not compromise AERB's effective independence.
- Providing necessary checks and balances, including opportunity of being heard and recording of basis, to ensure that its decisions and regulations are timely, clear, uniform and unambiguous and that all decisions are taken in a transparent manner and are based on sound, scientific and technical knowledge.
- Ensuring that its staff remain focused on performing their duties in relation to safety and are accountable for the same.
- Using effective means to communicate to and/or have consultation with stakeholders, as appropriate regarding its regulatory decisions and about any possible radiation risks associated with facilities and activities.
- Providing all members of society an easy access to relevant information so that they can reach an informed opinion on regulatory issues.
- Providing mechanisms for collection and use of feedbacks obtained from various regulatory processes for further improvements.

COMPOSITION OF THE BOARD

CHAIRMAN



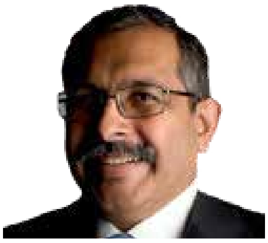
Shri Dinesh Kumar Shukla

CHAIRMAN, AERB

AERB BOARD MEMBERS

Shri S. B. Chafle
Executive Director, AERB
& Chairman, SARCOP

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



Prof. Devang V. Khakhar
Former Director, IIT, Mumbai,
Department of Chemical Engineering,
Indian Institute of Technology, Mumbai

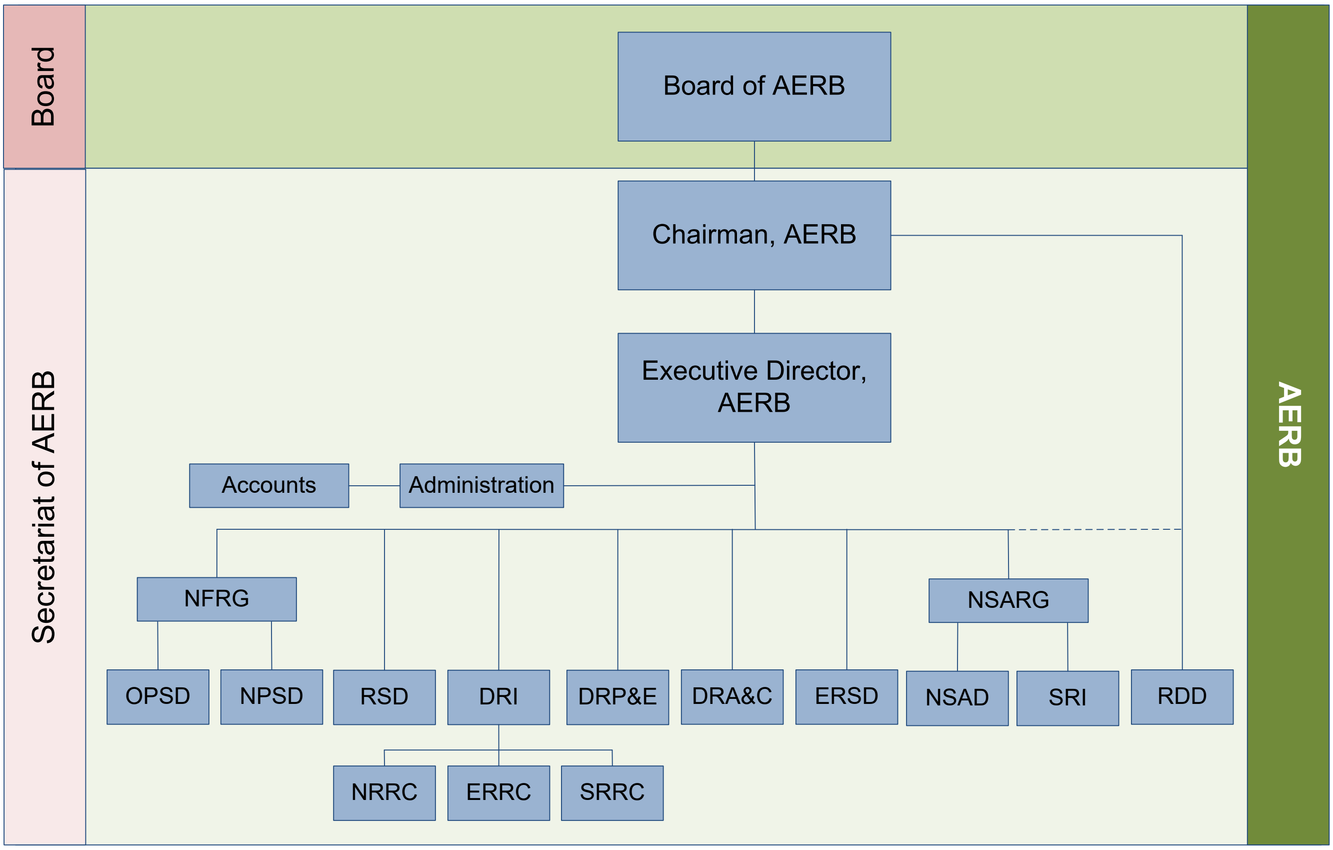
Dr. G. K. Rath
Ex Professor, Department of Radiation Oncology, AIIMS,
New Delhi, Chief Dr. B.R. Ambedkar Institute Rotary Cancer
Hospital, & Head National Cancer Institute, Jhajjar

Prof. M. Lakshmi Kantam,
Dr. B. P. Godrej Distinguished Professor,
Dept. of Chemical Engineering, Institute of Chemical
Technology (ICT), Mumbai

SECRETARY TO THE BOARD

Shri Makarand M. Kulkarni
Head, DRA&C

ORGANISATION CHART OF AERB



NFRG	Nuclear Facilities Regulation Group
NSARG	Nuclear Safety Analysis and Research Group
OPSD	Operating Plants Safety Division
NPSD	Nuclear Project Safety Division
RSD	Radiological Safety Division
DRI	Directorate of Regulatory Inspection
DRPE	Directorate of Radiation Protection and Environment
DRA&C	Directorate of Regulatory Affairs and Communications
ERSD	Emerging Regulatory Strategy Division
NSAD	Nuclear Safety Analysis Division
SRI	Safety Research Institute, Kalpakkam
R&DD	Resources and Documentation Division
RRCs	Regional Regulatory Centres

KEY INFORMATION AT A GLANCE FOR THE YEAR 2023

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Permissions for Procurement of Radioactive Sources	6,810
Permissions for Procurement of Radiation Generating Equipment	13,575
X-ray Equipment Licenced	29,089
Approvals for RSOs	5,589

EXECUTIVE SUMMARY

During the year 2023, Atomic Energy Regulatory Board (AERB) continued to monitor safety aspects of all facilities and activities associated with nuclear energy and applications of ionising radiation under its purview. AERB carried out its functions with the support of various safety committees and specialist committees.

Important Decisions by the Board

During the year, the Board met six times. The Board was periodically apprised of the important activities conducted by AERB and the safety status of the regulated installations. The important decisions by the Board are as follows:

a. Taking note of the measures being planned for strengthening the regulatory control over medical X-ray facilities, the Board accepted the proposal for closure of DRS model. To close the process of closure of DRS model in a systematic manner, the proposal has been forwarded to DAE for placing before AEC.

b. The Board suggested to develop practice specific guidelines for Proton Therapy based on the operating and regulatory experience gained. AERB has developed draft guidelines on regulatory requirements for establishing Proton Therapy Facility, which is under review.

c. The Board suggested wide dissemination of short awareness videos developed by AERB through social media to professional associations and all stakeholders. The video clips were uploaded on AERB website and on YouTube. Information circulars along with the links were sent to concerned parties.

d. The Board approved the revised Safety Standard on "Civil Engineering Structures Important to Safety of Nuclear Facilities AERB/NF/SS/CSE (Rev.1)".

Board Meeting of AERB

Safety Surveillance of Nuclear Facilities

Thirteen NPP units with a capacity of 10,100 MWe are under construction / commissioning stage.

Presently, civil construction and erection of major equipment are in progress at Kudankulam Nuclear Power Plant (KKNPP-3&4). AERB had issued Consent for Erection of Major Equipment in April, 2022.

In KKNPP-5&6, civil construction work is in progress. AERB gave permission for erection of Core Catcher Vessel in July, 2023. The Vessel has been installed.

Prototype Fast Breeder Reactor (PFBR) project is in commissioning stage. AERB is closely monitoring and reviewing the commissioning activities and related issues. Based on review, permission for pre-heating of Main Vessel was issued in April, 2023. Subsequently, permission for sodium filling in Main Vessel and commissioning activities up to 200°C was issued in August, 2023. AERB has also issued permission for raising the temperature of Primary Sodium in Main Vessel, Secondary Sodium System and Safety Grade Decay Heat Removal (SGDHR) system up to 250°C in November, 2023.

Kakrapara Atomic Power Plant (KAPP)-3, the first 700 MWe PHWR unit, is under Phase-C commissioning. After validating the modifications implemented to address the high area temperatures in Reactor Building, permission was granted for the resumption of commissioning and operation at 60% FP in March, 2023. Subsequently, permissions for raising KAPP-3 reactor power in steps were issued progressively. Permission for raising reactor power up to 100% FP was issued in August, 2023.

For KAPP-4, AERB issued permissions for PHT system Hot Conditioning & Light Water Commissioning and Initial Fuel Loading in June and October, 2023 respectively. On completion of Initial Fuel Loading and satisfactory safety review, permission was issued for Bulk Addition of Heavy Water to the moderator system and First Approach to Criticality and Low Power Physics Experiments in December, 2023. KAPP-4 achieved its first criticality on December 17, 2023.

For Rajasthan Atomic Power Plant (RAPP)-7, AERB issued permission for PHT system Hot Conditioning and Light Water Commissioning in November, 2023. Hot Conditioning of PHT system was completed and currently Light Water Commissioning related tests are in progress. At RAPP-8, Construction/ Pre-commissioning activities are in progress.

The permission for the commencement of raft construction for the Nuclear Building (NB-1) at Gorakhpur Haryana Anu Vidyut Pariyojna (GHAVP-1&2) was issued on March 16, 2023. AERB was subsequently notified of subsidence in some of the ground improved area near Station Auxiliary Building of GHAVP-2. NPCIL is conducting investigations to establish the cause and extent of the problem.

AERB continued regulatory oversight of 22 operational NPP units in India. The radioactivity releases from all the NPPs were less than the AERB specified limits. Effective dose to member of public in the vicinity of NPP sites was far less than the annual dose limit of 1 mSv.

AERB renewed the Licences for Operation under the Atomic Energy Act, 1962 (and rules framed thereunder), the Factories Act, 1948 (and rules framed thereunder) and issued Authorization for radioactive waste disposal / transfer under the Atomic Energy (Safe Disposal of Radioactive

Wastes) Rules, 1987 for KGS-3&4 and NAPS-1&2. RAPS-3 is under shutdown since October 27, 2022 for En-masse Coolant Channel Replacement (EMCCR) and En-masse Feeder Replacement (EMFR).

AERB continued to review the safety aspects of operating Nuclear Fuel Cycle facilities under its purview. AERB issued the Licence for Operation of mines at Jaduguda, Narwapahar, Turamdih, Bhatin & Tummalapalle. AERB also issued the License for Operation of HWP-Hazira and extended the validity of license for operation of HWP-Tuticorin.

During the year, AERB also renewed the License for Operation of IGCAR facilities viz. FBTR, IFSB, CORAL, RML and RCL. Details of licenses / consent issued to Operating Nuclear Power Plants, Research Reactors, Nuclear Fuel Cycle Facilities and other related Industrial Facilities are given in section 1.6.

Safety Surveillance of Radiation Facilities (RF)

AERB issued 25,623 licences for operation of various Radiation Facilities (RFs) involved in use of ionising radiation in medical, industrial and research activities. AERB also issued 6,810 permissions for procurement of radioactive sources and granted 5,589 approvals for Radiation Safety Officer (RSOs) in various practices.

Enforcement actions in the form of suspension of license for operation was taken against Industrial Radiography facilities in Mathura, Trichy, Delhi and Ahmednagar due to non-adherence to Personnel Monitoring Service (PMS), engaging untrained personnel, use of enclosure without valid consent and higher radiation levels outside the radiography enclosure, and falsely declaring RSOs.

The details of Safety Surveillance of Radiation Facilities are given in Chapter-2.

Regulatory Inspection (RI) of Nuclear and Radiation Facilities

AERB conducted 129 RIs in various nuclear power projects, operating NPPs, and Industrial & fuel cycle facilities and 942 RIs in various medical, industrial and research facilities, to check compliance with the licensing conditions and relevant safety requirements. Site Observers Teams (SOT) are posted at four NPP sites (Rawatbhata, Kalpakkam, Kakrapar and Kudankulam) to observe activities at the operating as well as the under construction plants. There was no 'Red' category inspection findings observed in Nuclear and Radiation facilities during the year. Red category finding relates to a deviation of high safety significance and need urgent corrective action by the facility. The details of Regulatory Inspection of Nuclear and Radiation Facilities are given in Chapter-3.

Environmental Safety and Occupational Exposure (for the year 2022)

Radioactive effluent releases from all the licensed facilities remained within the authorized limit. Public dose to a hypothetical person considered to be present at the exclusion zone boundary of NPP was estimated to be between 0.002 μSv – 25.35 μSv, which is a small fraction of the public dose limit (1000 μSv). Occupational doses in the NPPs, nuclear fuel cycle facilities and radiation facilities were monitored at defined frequency. There was no case of individual exposure above regulatory dose limit for the regulated nuclear and radiation facilities.

Details of public doses, occupational doses and initiatives taken by AERB for dose reduction are presented in Chapter-4.

Emergency Preparedness

Plant/Site/Off-Site emergency exercises were conducted at NPP sites as per the defined frequencies. Off-Site Emergency Exercises (OSEE) were observed by AERB officials and monitored through Nuclear and Radiological Emergency Monitoring Centre (NREMC) of AERB. Site Emergency Exercises were conducted at seven NPP sites and Table-Top Off-Site Emergency Exercises (OSEE) were conducted at five NPPs.

The status of Emergency Preparedness are presented in Chapter 5.

Regulatory Safety Document Development

Fifty Two safety documents are under different stages of development / revision. During the year, a revised Safety standard on 'Civil Engineering Structures Important to Safety of Nuclear Facilities' was published. As part of India's contribution to the safety standards programme of IAEA, AERB reviewed and provided comments on number of draft Safety Standards of IAEA.

The status of Regulatory Safety Documents is presented in Chapter- 6.

Safety Analysis, Research and Development

To support the regulatory review functions of AERB, safety studies are performed in the area of reactor physics, thermal-hydraulics, structural mechanics, severe accidents, radiological impact assessment and environmental chemistry.

Safety assessment of low power reactor physics experiments during 7th fuel cycle operation of KKNPP-1 was carried out. Independent verification studies were conducted for safety review of proposal for loading of RU/SEU fuel bundles in PHWR-220.

Severe accident studies included estimation of critical heat flux and in-vessel retention capability of PHWRs, extended SBO event analysis for PHWR-700, effect of non-availability of one or more PDHRS loops and analysis of core disruptive accident scenario in a MOX fuelled reactor.

Experimental studies were conducted in the Compartment Fire Test Facility (CFTF) at SRI to determine the fire hazard potential of turbine lube oil. The behaviour of Iodine in reactor containment during postulated accidental conditions was investigated in an in-house experimental facility. Studies on sorption of Iodine species using silver-doped alumina were also undertaken and completed.

Structural mechanics studies included deterministic analysis of BWR reactor pressure vessel using FAVOR Code, high temperature creep and rupture behaviour of calandria material SS 304L, assessment of PHWR-700 primary containment integrity for internal pressure, participation in Standard Problem Exercise (SPE) related to seismic soil-structure interaction in collaboration with the USNRC to evaluate the effectiveness of frequency domain method for analysing deeply embedded structures.

AERB renewed funded research projects on nuclear, radiation and industrial safety at academic institutions under the AERB-Safety Research Programme. Seven on-going projects were renewed / extended this year.

The details on various activities of Safety Analysis and Research are presented in Chapter-7.

Stakeholders Engagement & Public Outreach Activities

AERB conducted various programs to keep its stakeholders and public informed. Toward this, AERB organised National Conference on Regulatory Interface (NCRI-2023) on "Safety Regulations in Mining, Milling and Fuel Fabrication Facilities", 39th DAE Safety and Occupational Health Professional Meet and organised number of awareness programs for stakeholders. AERB also conducted public awareness programs in the vicinity of NPPs viz. Kakrapara, Gorakhpur and Rajasthan sites for school children, college students and teachers.

AERB also conducted various awareness programs for stakeholders of radiation facilities.

AERB provided information to stakeholders through its annual report, quarterly e-newsletters, press releases / briefings, etc., which are available on the website of AERB, www.aerb.gov.in.

The details on Stakeholders Engagement & Public Outreach Activities are presented in Chapter-8.

Accountability

AERB provided timely responses to the queries posted by the members of public under Right to Information (RTI) Act, 2005 and Public grievances. It also submits responses to parliamentary questions related to regulation of NRFs. The details on Public Accountability Activities are presented in Chapter-9.

International Co-operation

Chairman AERB, led Indian delegation consisting of experts from AERB, Bhabha Atomic Research Centre, Nuclear Power Corporation of India Limited and the India's Permanent Mission in Vienna, to participate in Joint 8th and 9th Review Meeting (RM) of the Convention on Nuclear Safety (CNS) at Vienna, Austria held during March 20-31, 2023. The National Report of India for peer review was presented on March 21, 2023. The presentation of India highlighted noteworthy practices in India's nuclear programme, response to challenges and suggestions identified in the previous RMs and areas of good performance in India's safety & regulatory framework. India was commended for seven Areas of Good Performance. Shri S B Chafle, Executive Director, AERB, chaired the Country Group-5 review meetings in CNS.

Chairman, AERB, as part of Indian delegation, attended the 67th IAEA General Conference held during September 25 - 29, 2023 at Vienna, Austria. He also attended the Senior Safety and Security Regulator's meet and side-line meetings with delegation from regulatory bodies of Slovak Republic, Vietnam and Argentina arranged during the General Conference.

AERB signed a MoU with Nuclear Regulatory Authority of the Slovak Republic (UJDSR) on September 25, 2023 for the exchange of technical information and co-operation in the field of regulation of the safe use of nuclear energy for peaceful purposes.

A bilateral meeting with United States Nuclear Regulatory Commission (USNRC) was held at AERB Headquarter, Mumbai during February 13-15, 2023.

AERB actively participates and contributes in the multi-lateral international activities organized by International Atomic Energy Agency (IAEA) and Nuclear Energy Agency (NEA).

The details on AERB's contributions in the areas of International Co-operation are provided in Chapter-10.

Human Resource Development and Infrastructure

AERB continued to augment its human resources with recruitment of personnel at various levels considering the safety regulation needs of expanding nuclear power programme of India and increasing number of radiation facilities in the country. This is being carried out through induction of Graduate Trainees from Orientation Course for Engineering Graduates and Science Post Graduates (OCES) of DAE units and direct recruitment mode.

As striving towards workplace excellence, AERB conducted two opinion surveys of its staff pertaining to assessment of organisational climate and participation of staff in policy making. The first survey was an attempt to elicit views/ opinion of employees of AERB on eligibility cum selection criteria for choosing the 'right person' for heading a Division/Directorate in AERB. The second survey was designed to elicit feedback on the attributes the employee thinks are important towards assessment of their superiors, namely the immediate superior, Section Head and Division Head.

The details on Human Resource & Infrastructure Development and initiatives towards organisational climate excellence are provided in Chapter-11.

Events and Activities for AERB Employees

AERB organised various activities such as Republic day, Swachhata Pakhwada, National Safety Day, and International Women's Day, etc. to engage with the employees.

The details on Events and Activities for AERB Employees are presented in Chapter-12.

Official Language Implementation

AERB celebrated National Hindi Day, World Hindi Day and conducted a variety of programs to promote and encourage the use of Hindi as the official language in its official works.

The details on Official Language Implementation are presented in Chapter-13.

Finance

AERB receives funds from the Government of India for meeting its revenue and capital expenditure. The annual expenditure during the year 2022-23 was Rs.114.89 Cr.

The details on Finance is presented in Chapter-14.

AERB FORMATION DAY
RUBY JUBILEE ANNIVERSARY

AERB FORMATION DAY-RUBY JUBILEE ANNIVERSARY

Dignitaries Present During Celebration of AERB Day 2023

Lighting of Lamp During the Celebrations

Dignitaries Attending Celebration of AERB Day 2023

AERB FORMATION DAY-RUBY JUBILEE ANNIVERSARY

On November 15, 2023, AERB celebrated its Ruby Jubilee Anniversary, having completed forty years since its formation, and organized activities focused on introspection and strategizing the way forward.

AERB decided to observe journey for transformative 41st year as 'SANKRANTI KAAL'. This KAAL (period) is being observed by conducting round the year activities of introspection, retrospection through intensive staff interactions (i.e. process of "MANTHAN") for transitioning to future readiness state. This "MANTHAN" process assumes significance in view of challenges posed by the national plans to expand the nuclear power programme in a big way by deploying mix of existing and emerging technologies through joint ventures and public- private partnerships (PPP).

The subsequent paragraphs detail AERB's journey so far and illustrate, how through "MANTHAN", the organization is adapting to meet evolving regulatory needs.

Formative Years and Consolidation Phase (1983- 2008)

AERB inherited the good practices and attributes of safety governance evolved in the initial days by its predecessors. Development of practical regulations evolved with the experiences gained from the concurrent development of technology with the strong backing of a long-term R&D programme. With limited number of staff and modest resources at its disposal, AERB devised a mechanism which was suitable at that point of time. While retaining the basic framework of multitier reviews which evolved from initial days of research reactor operations at CIRUS, AERB started utilising the knowledge base available within DAE and other premiere academic institutes. The multitier safety review structure of AERB, with participation of external experts, progressively evolved and strengthened and slowly became the hallmark of AERB's regulation. Over the years, AERB steadily built its own pool of competent human resource, which AERB values as its important asset for maintaining independence.

The Introspection and Transformative Phase (2009-2023)

Around 2010, AERB witnessed series of challenging situations such as the Mayapuri incident, Fukushima nuclear accident, Kudankulam nuclear power plant protest and litigations followed by first time performance audit of AERB by CAG. AERB also hosted the IRRS peer review mission for the first time in 2015 which also provided various suggestions and recommendations for improvement besides recognising strength areas. This prompted AERB to carry out an in-depth introspection of its practices holistically and to undertake improvements.

These efforts were essential in addressing the evolving challenges within the nuclear sector and aligning with global best practices. With transformed outlook and beliefs, some novel approaches were conceived. Some of the major changes taken up were:

- **Introduction of Web based e-Licensing of Radiation Applications(e-LORA)**

  To enhance the management of radioactive sources and facilitate business operations, AERB introduced the e-Licensing of Radiation

Applications (e-LORA) platform. This state-of-the-art web-based system represents a milestone in regulating radiation facilities across the country, streamlining processes, and ensuring radioactive source inventory management.

- **Competency Building and Emphasis on Self Reliance**

  AERB developed a structured program aimed to enhance the competency of its staff and allocating them more responsibilities. This program emphasized self-reliant in-house reviews, which were supplemented by reviews from external experts and committees. The approach maintained an objective, participative, and inclusive decision-making process while ensuring that it remained non-intrusive.

- **Influenced Self–Regulation among Licensees**

  AERB developed approaches towards encouraging licensees to self-regulate and recognize safety issues independently. This led to significant improvements in the safety performance of licensed units and fostered a positive licensee-regulator relationship.

- **Revamped Regulatory Inspection Strategy**

  Comprehensive measures were taken to streamline, harmonize and update the regulations and to improve the regulatory processes. Regulatory inspection methodology was revamped to factor in the programmatic part, for deciding the scope and frequency of inspections. AERB also started posting resident site observer teams to improve regulatory presence at the co-located operating and construction sites of nuclear power plants.

- **Strengthened Emergency Preparedness and Response**

  Learning from the Fukushima incident, AERB updated its emergency preparedness and response strategies. The plan was revamped to assign decision-making responsibilities to plant management, while district authorities were responsible for implementing response actions. Table-top exercises were introduced to assess operator's decision-making capabilities during crisis conditions.

- **Strengthening Regulatory Interface with Line Ministries**

  Another area which AERB stressed upon was to understand and appreciate the key difference in control and safety regulation. AERB realized that for effective regulation of radiation facilities it is important to also leverage the national machinery and resources provided through various statutory framework. Towards this, AERB identified the nodal agencies and has started interacting with them for a cohesive regulatory interface for simplified and pragmatic regulations.

- **Enhanced Stakeholder Engagements**

  Further, AERB augmented its stakeholder engagement by having annual conferences for collecting feedback from its stakeholders, awareness programmes in the vicinity of nuclear power plants, media personnel, etc.

- **Adaptation during COVID-19 Pandemic**

  The COVID-19 pandemic posed a significant challenge to the regulatory inspection program, as movement restrictions across the country made traditional inspection methods difficult. In response, AERB developed a remote regulatory inspection process to maintain oversight of licensed activities and facilities. Leveraging computer networking infrastructure, including video conferencing systems, AERB created an inclusive environment for communication with stakeholders. These innovative approaches ensured that regulatory standards were being maintained even during the pandemic, demonstrating AERB's adaptability and commitment to safety.

Completion of 40 Years: Ruby Jubilee Celebration

To commemorate its 40th anniversary, AERB organized talks by key speakers, highlighting its journey, challenges faced, lessons learned, and introspective measures taken to improve regulations and practices.

Stalwarts of Indian nuclear fraternity came together to extend their wishes to AERB on this momentous occasion. Dr. A. K. Mohanty, Chairman, Atomic Energy Commission, Shri Vivek Bhasin, Director, Bhabha Atomic Research Centre, former Chiefs of Atomic Energy Commission Dr. R. K. Sinha and Dr. K. N. Vyas, former Chairpersons of Atomic Energy Regulatory Board Shri S. S. Bajaj and Shri S. A. Bhardwaj, esteemed AERB Board members Prof. Harsh Gupta and Prof. Lakshmi Kantam along with other distinguished luminaries appreciated the progress made by AERB during the glorious four decades. They also provided their insights on the future challenges and expressed their confidence in AERB's capabilities to meet these challenges. Chairman, AERB recollected the guidance provided by eminent delegates during the silver jubilee celebration held in 2008 and summarised how AERB had worked on those guidance for preparing itself for future challenges.

Adapting to New Regulatory Needs

With the anticipated expansion of nuclear energy through joint ventures, PPP models, number of PHWR reactors, foreign design advanced reactors, and the aging of old reactors there is a need to address the increased complexity and diversity of nuclear technologies, ensure the continued safety and security of both new and existing facilities, and foster a regulatory environment that supports innovation while maintaining stringent safety standards.

In view of above, following actions have been contemplated and being implemented:

- **Revisiting and Overhauling Regulation**

  Updating regulations to make them technology-neutral,entity-independent and non-prescriptive. Structured programs are being developed to obtain feedback from relevant stakeholders for continuous improvement.

- **Applying a Graded Approach Strategy**

  This strategy is applied across various regulated facilities and activities. Regulatory processes are designed to ensure that regulatory actions are proportionate to the risk, considering the complexity of design, repeat designs, first-of-a-kind systems, or emergent concepts.

- **Revamping Human Resource Policy**

  Updating human resource policy to emphasize competence management, ensuring that staff are well-prepared to meet current and future regulatory challenges.

- **Adopting Smart Regulatory Approaches**

  Adopting strategies to ensure that regulatory efforts are efficient and effective, balancing hard work with smarter choices.

- **Integrating Regulatory Oversight**

  Safety review and assessment are complemented by regulatory inspections, ensuring comprehensive regulatory oversight.

- **Strategizing Regulatory Research**

  Conducting regulatory research for supporting decision-making processes by undertaking in-house research, collaborative projects with premier research institutes, and sponsored projects in academic institutions.

- **Engaging Stakeholders**

  Developing strategies for engaging with various stakeholders in an open and transparent manner. Engagement activities range from providing information and increasing radiation literacy to more involved interactions such as consultation and feedback collection.

Within forty years of its existence, AERB has established the necessary regulatory infrastructure and demonstrated its capability to shoulder greater responsibilities. AERB has gradually flourished making its presence felt in national and international arena. With a transformed outlook and ongoing efforts in above areas, AERB continues to perform its regulatory activities effectively, ensuring the safety and security of nuclear and radiation facilities in India.

CHAPTER-01

SAFETY SURVEILLANCE OF NUCLEAR & DAE INDUSTRIAL FACILITIES

SAFETY SURVEILLANCE OF NUCLEAR & DAE INDUSTRIAL FACILITIES

Nuclear and Industrial facilities in India are sited, designed, constructed, commissioned, operated and decommissioned in accordance with strict quality and safety standards. The primary responsibility for the safety of the facility lies with the licensee. All these facilities undergo an in-depth safety review during various stages as per AERB's established regulatory framework. The objective of safety review and assessment at various stages of a facility is illustrated below:

Siting

To ensure that the selected site is suitable for the proposed facility and meets criteria for site evaluation.

Construction

To ensure that the design of the proposed facility meets the regulatory requirements, the construction is as per the approved design and verify the construction methodology vis-à-vis design requirements.

Commissioning

To ensure that the commissioning programme meets the regulatory requirements; performance of the plant is as per design intent and results of commissioning tests confirm adequacy of the plant design.

Operation

To ensure that plant operates within approved limits & conditions, adequate level of safety is maintained through administrative control and adherence to procedures, availability of qualified manpower meets the licensing requirements as prescribed by AERB and management systems are established for safe operation.

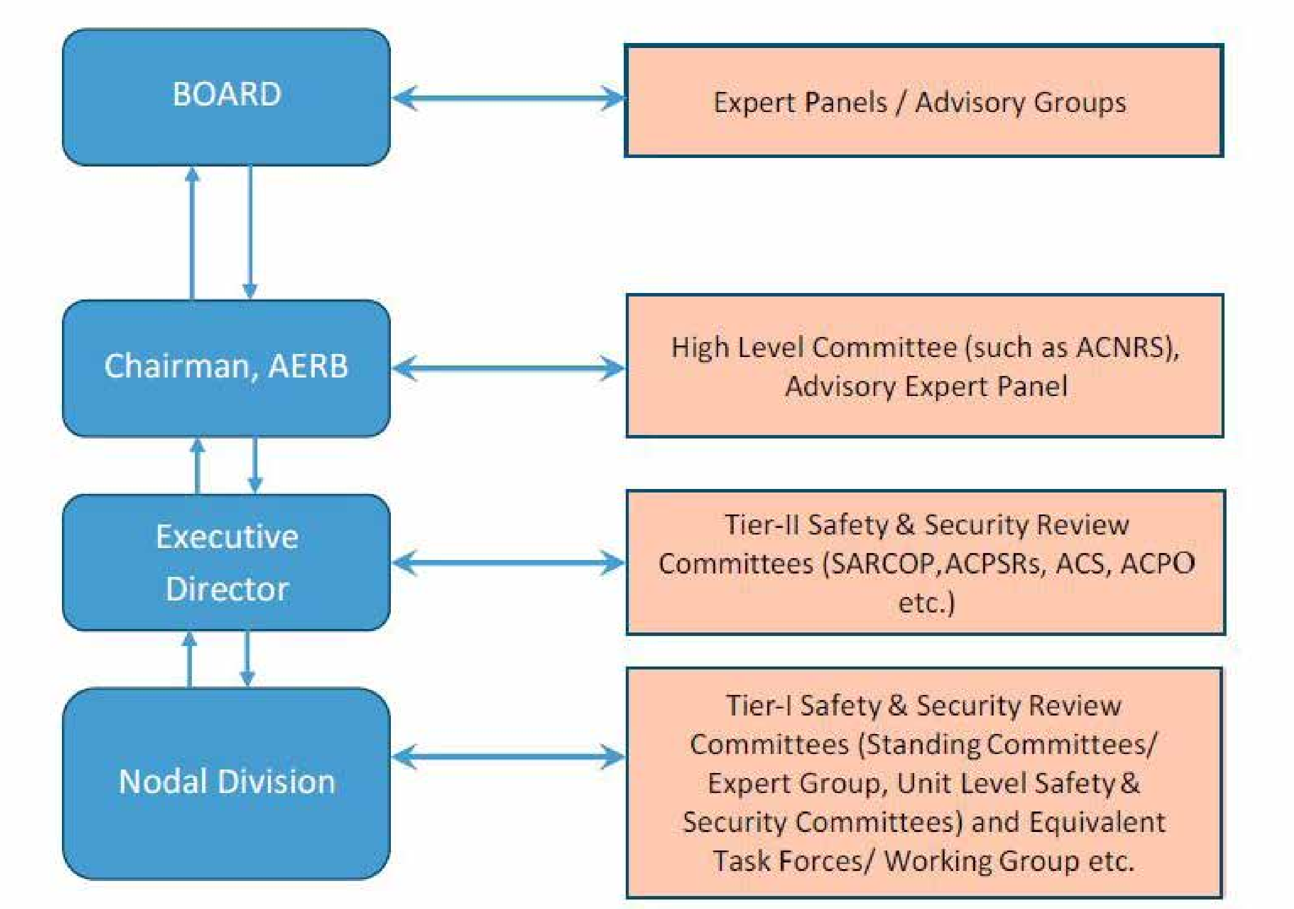
1.0 Safety Review Mechanism of Nuclear and Industrial Facilities

Review of Safety Aspects

AERB follows a multi-tier system of safety review. The scope and depth of safety review in AERB is based on graded approach. Issues of greater safety significance are given consideration at higher level for their satisfactory resolution.

AERB derives support from a number of safety committees for safety review and assessment activities. The safety committees include experts in relevant fields, including nuclear and radiation safety. Expertise of members from academia, national R&D institutes and government bodies are utilised in higher level committees. Recommendations of these committees concerning various safety issues and their consents are further considered in AERB for arriving at the regulatory decisions. This arrangement ensures comprehensiveness of the reviews and effective compliance with the specified requirements. AERB carries out periodic regulatory inspections to check conformance with regulatory requirements and consenting conditions.

The licence for operation of the facilities is issued after ensuring its satisfactory construction and commissioning as per the approved design and the specified safety/regulatory requirements. The



Multitier Safety Review System of AERB

licence for operation is issued with a specified validity period.

The operating facilities are subjected to a comprehensive Periodic Safety Review (PSR) every ten years. 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. This regulatory approach ensures that the safety levels of the plants are maintained and enhanced to remain comparable with the current safety standards /practices throughout the operating life of the plant.

Review of Security Aspects

AERB is also entrusted with the responsibility of review and assessment of nuclear security aspects (that have bearing on safety) for different types of nuclear and industrial facilities under its purview. AERB has issued various regulatory documents specifying nuclear security and cyber security requirements for nuclear and industrial facilities. Security aspects are reviewed against relevant regulatory requirements. Multi-tier approach is adopted for review of security aspects also.

1.1 Review Status of Nuclear Power Projects & Fuel Cycle Facilities

The status of various nuclear power projects under siting, construction and commissioning are presented in Table 1.1.

Table 1.1: Status of Nuclear Power Projects

Project Stage	Project	District/ State	Utility/ Licensee/ Applicant	Type	Review Status
Siting	Mahi Banswara Rajasthan Atomic Power Project -1-4	Banswara/ Rajasthan	NPCIL	700 MWe PHWRs	Initial Reviews Towards Admittance of Siting Application Completed
Construction	Kudankulam Nuclear Power Project -3&4	Tirunelveli/ Tamil Nadu	NPCIL	1000 MWe VVERs (LWRs)	Consent for Erection Of Major Equipment (MEE) Issued in April, 2022.
	Kudankulam Nuclear Power Project - 5&6	Tirunelveli/ Tamil Nadu	NPCIL	1000 MWe VVERs (LWRs)	Clearance for First Pour of Concrete issued on May 12, 2021
	Gorakhpur Haryana Anu Vidyut Pariyojana -1&2	Fatehabad/ Haryana	NPCIL	700 MWe PHWRs	Consent for FPC was issued in November, 2020. Permission for Commencement of Raft NB-01 issued in March, 2023.
	Rajasthan Atomic Power Project -7&8	Chittorgarh / Rajasthan	NPCIL	700 MWe PHWRs	Reviews related to Pre-commissioning Activities in Progress
	Kaiga Nuclear Power Project - 5&6	Karwar / Karnataka	NPCIL	700 MWe PHWRs	Excavation Consent was issued in March, 2022.
Commissioning	Prototype Fast Breeder Reactor, Kalpakkam	Kancheepuram/ Tamil Nadu	BHAVINI	500 MWe Prototype Fast Breeder Reactor	Reviews for Phase-A Commissioning Activities in Progress.

Project Stage	Project	District/ State	Utility/ Licensee/ Applicant	Type	Review Status
	Kakrapar Atomic Power Project - 3&4	Tapi, Gujarat	NPCIL	700 MWe PHWRs	For Unit -3, Permission for raising Reactor Power up to 100% FP was issued in August, 2023 For Unit-4, Permissions issued for Bulk Addition of Heavy Water to the Moderator System and First Approach to Criticality and Low Power Physics Experiments in December, 2023

1.2 Nuclear Power Projects: Review Status

Safety review activities related to the Nuclear Power Projects (refer Table 1.1) continued during the year 2023. The review status is as follows:

1.2.1 Light Water Reactor based Nuclear Power Projects

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

AERB had issued Consent for Erection of Major Equipment (MEE) in April, 2022. Currently civil construction and erection of equipment is in progress at KKNPP-3&4 site.

In KKNPP-3, welding of Main Coolant Pipelines (MCP) has been completed. AERB conducted a special regulatory inspection for witnessing the welding activities. Concreting of Inner Containment (IC) dome in Reactor Building of Unit-3 is completed.

In KKNPP-4, Safety System pumps have been installed in all the safety trains.

View of Main Plant Buildings of KKNPP-3

1.2.1.2 Kudankulam Nuclear Power Project (KKNPP) - 5&6

AERB had issued Consent for First Pour of Concrete (FPC) in May, 2021.

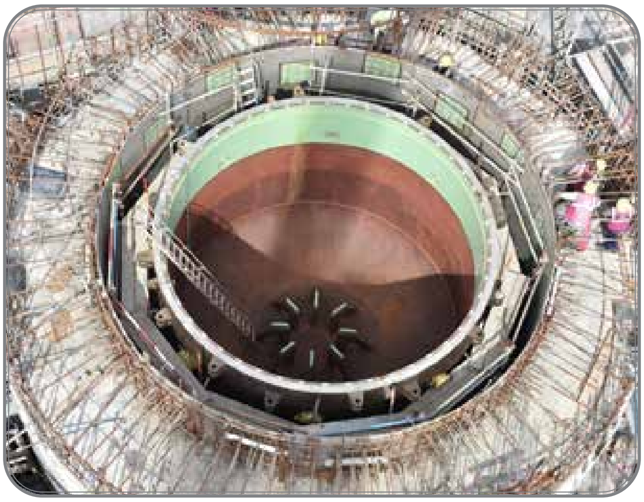
Presently, civil construction work is in progress at KKNPP-5&6. Based on satisfactory safety review, permission for erection of Core Catcher Vessel was issued and the Vessel was installed in KKNPP Unit-5 in July, 2023.

View of Containment Dome of KKNPP-3

Overview of KKNPP-5 Reactor Building

View of Main Plant Buildings of KKNPP-4

Overview of KKNPP-6 Reactor Building



Core Catcher Installation in KKNPP-5

1.2.2 Prototype Fast Breeder Reactor (PFBR)

Prototype Fast Breeder Reactor (PFBR) project is in commissioning stage. Safety review of Phase-A commissioning activities is in progress.

Prototype Fast Breeder Reactor

Based on review, permission for pre-heating of Main Vessel was issued in April, 2023. And subsequently, after satisfactory review, permission for sodium filling in Main Vessel and commissioning activities up to 200°C was issued in August, 2023. Later, on completion of sodium filling activity and review of its commissioning tests results, AERB issued permission for testing of fuel handling systems at 200°C in September, 2023.

BHAVINI also submitted an application for raising the temperature of primary sodium in Main Vessel, Secondary Sodium System and Safety Grade Decay Heat Removal (SGDHR) system up to 250°C and carry out the performance test of SGDHR loops. Based on the satisfactory review, permission was issued in November, 2023.

In December 2023, BHAVINI reported leaks in one of the air heat exchangers of SGDHR system. Investigations for the cause of leaks are in progress and methodology for corrective actions is under review in AERB.

AERB is closely monitoring and reviewing the commissioning activities and related issues. AERB has also conducted special regulatory inspection to witness the tests / activities being carried out during the commissioning phase.

1.2.3 Pressurized Heavy Water Reactors (PHWR) based Nuclear Power Projects

1.2.3.1 Kakrapar Atomic Power Project (KAPP)-3&4

KAPP-3 attained first criticality in July 2020. As

Meeting of Project Design Safety Committee at Kakrapar Site

part of commissioning clearance, permission to raise the Reactor Power to 50% Full Power (FP) for power ascension tests was issued in November 2020. Subsequently, KAPP-3 was synchronized to the grid in January 2021.

NPCIL carried out modifications in the ventilation system and certain structures to address high temperatures in some areas of the Reactor Building (RB). After validation of these modifications, permission for resumption of Phase-C commissioning & reactor power operation of KAPP-3 up to 60% FP was issued in March, 2023. Subsequently, permissions for

Project Design Safety Committee Members with NPCIL Officials at KAPP-3&4

raising KAPP-3 reactor power to 70% FP, 80% FP, 90% FP and 100% FP were issued progressively and the commissioning results were reviewed by AERB. Permission for raising reactor power up to 100% FP was issued in August, 2023.

Similar to KAPP-3, modification works were carried out in KAPP-4 ventilation systems and certain structures in some of the reactor building areas. After safety review in AERB, permissions for KAPP-4 PHT system hot-conditioning & light water commissioning and initial Fuel Loading were issued in June and October, 2023 respectively. On completion of initial fuel loading and satisfactory safety review, permissions were issued for bulk addition of heavy water to the moderator system and first approach to criticality and low power physics experiments in December, 2023. KAPP-4 achieved its first criticality on December 17, 2023 and presently low power physics experiments are in progress.

Fuel Handling Control Panel of KAPP-3

View of Turbine Generator of KAPP-3

1.2.3.2 Rajasthan Atomic Power Project (RAPP) - 7&8

Based on the commissioning review experience of KAPP-3&4, modifications were carried out in some of the areas of the Reactor Building (RB) of RAPP-7. Also, necessary changes were incorporated in the commissioning procedures. Permission for RAPP-7 PHT system Hot Conditioning and light water commissioning was issued in November, 2023. After completion of hot conditioning, light water commissioning related tests are in progress in RAPP-7. At RAPP-8, construction/ pre-commissioning activities are in progress.

Rajasthan Atomic Power Project (RAPP)-7&8

1.2.3.3 Gorakhpur Haryana Anu Vidyut Pariyojana (GHAVP) -1&2

AERB issued permission for First Pour of Concrete for GHAVP-1&2 in November 2020. Subsequently, ground improvement works and construction of foundation piles in the Nuclear Building (NB) area were completed. In December 2022, NPCIL submitted request for resumption of further construction activities i.e. commencement of NB-1 raft construction. Considering the results of repeat NDT of foundation piles and revised analysis/ design of NB, permission for the commencement of raft construction of NB-1 at GHAVP-1&2 was issued on March 16, 2023.

AERB was subsequently notified of ground subsidence in some of the GI (Ground Improvement) area near Station Auxiliary building (SAB) of GHAVP-2. NPCIL is carrying out investigations to establish the cause and extent of the problem.

GHAVP Project Site

1.2.3.4 Kaiga Atomic Power Project (KAIGA)-5&6

Consent for siting and consent for excavation for KAIGA-5&6, was issued by AERB in November, 2020 and March, 2022 respectively. Excavation activities at Kaiga-5&6 Main Plant area are in progress.

NPCIL submitted an application for First Pour of Concrete (FPC) for Kaiga-5&6 in July 2022. The application was reviewed in AERB. NPCIL has been asked to revise the application and submit additional supporting documents for further review in AERB. The documents are being submitted progressively by NPCIL.

1.2.3.5 Mahi Banswara Rajasthan Atomic Power Project (MBRAPP)-1 to 4

Application for Siting Consent of Mahi Banswara Rajasthan Atomic Power Project Units 1 to 4 (MBRAPP 1 to 4) along with supporting documents was submitted. Adequacy review of the application and supporting documents has indicated that additional information is needed to admit the application for review.

1.3 Fuel Cycle Facility Projects

The status of various fuel cycle facility projects under siting, construction and commissioning are presented in Table 1.2.

Table 1.2: Status of Fuel Cycle Facilities under Siting, Construction and Commissioning

Project Stage	Project	Dist./ State	Utility/ Licensee/ Applicant	Review Status
Siting	Additional Away From Reactor Spent Fuel Storage Facility for RAPS	Chittorgarh / Rajasthan	NPCIL	Review of Siting application is in progress
Construction	Away From Reactor Spent Fuel Storage Facility for KKNPP-3&4	Tirunelveli/ Tamil Nadu	NPCIL	Construction Consent was issued in September, 2022.
	PHWR Fuel Fabrication Facility & Zircaloy Fabrication Facility, Rawatbhata.	Chittorgarh/ Rajasthan	Nuclear Fuel Complex, Kota	Construction Consent was issued in February 2018. Review of submissions related to Commissioning Consent is in progress.

1.4 Fuel Cycle Facility Projects: Review Status

Safety review activities related to the Fuel Cycle Facility Projects (refer Table 1.2) continued during the year 2023. The review status is as follows:

1.4.1 Additional Away From Reactor spent Fuel Storage Facility for RAPS (AAFR)

NPCIL submitted Application for Siting consent for the Additional Away From Reactor (AAFR) Spent Fuel Storage Facility at Rawatbhata Rajasthan site. Based on intial review, NPCIL was asked to submit additional information in support of the application.

1.4.2 KKNPP-3&4 Away From Reactor (AFR)

Based on review, Construction Consent for KKNPP-3&4 AFR was issued in September, 2022. First pour of concrete for the facility commenced in October, 2022 and raft concreting was completed in January, 2023. NPCIL submitted an application for construction of inner pool of AFR, which was one of the regulatory hold points of the Construction Consent. The application was reviewed in AERB and permission for construction of inner Pool of AFR was issued in October, 2023.

AFR of KKNPP-3&4

1.4.3 KKNPP-1&2 Away From Reactor (AFR)

AERB had issued Siting Consent in May, 2021 subject to compliance to certain stipulations. Application for Excavation Consent was treated as lapsed for want of submissions of required supporting documents.

1.4.4 Nuclear Fuel Complex, Kota (NFC-K)

500 Tons Per Annum (TPA) PHWR Fuel Fabrication Facility (PFFF) and 165 TPA Zircaloy Fabrication Facility (ZFF) are being setup at Nuclear Fuel Complex (NFC), Kota. In first phase, two modules of 250 TPA PFFF and 65 TPA ZFF are planned to be set up. Construction Consent to NFC-Kota was issued in February, 2018. The validity of construction consent of NFC-Kota was extended till December 31, 2024 based on review of NFC-Kota's request to complete ongoing civil works. Presently, installation of major equipment and cold commissioning of Zircaloy Fabrication Facility (ZFF) and PHWR Fuel Fabrication Facility (PFFF) are in progress.

NFC-Kota submitted proposals to conduct demonstration activities related to end cap welding and machining & end plate welding of the fuel bundles. These proposals were reviewed and permissions for one time-demonstration of these activities were issued in April and June, 2023 respectively. NFC-Kota successfully conducted these demonstration activities.

NFC Kota Project Site

The information on the meetings of the important safety review committees for facilities undergoing reviews related to siting / construction/ commissioning is given in Table 1.3.

Table 1.3: Safety Review Committee Meetings of the Nuclear Power Projects and Fuel Cycle Facilities under Construction

Project Safety Committee	Number of Meetings
Advisory Committee for Project Safety Review (ACPSR-NPPs) (for PHWRs, PFBR & LWRs)	07
Project Design Safety Committee – Fast Breeder Reactor (PDSC-FBR)	08
Project Design Safety Committee – Light Water Reactors (PDSC-LWR)	01
Project Design Safety Committee- Pressurized Heavy Water Reactors (PDSC-PHWR)	22
Civil Engineering Safety Committee (CESC)	02
Committee for Reviewing Security Aspects (CRSA)	02

1.5 Reportable Industrial Incidents at Construction Sites

1.5.1 KKNPP–3 to 6

In KKNPP 3&4, one reportable accident occurred in January 2023 which involved fall of a contract worker from a height of ~6 meters through an opening in a steel platform. The opening in the steel platform was provided to facilitate laying of temporary flexible duct for air conditioning and ventilation inside the reactor pressure vessel.

In KKNPP-5&6, one reportable accident occurred in February, 2023 which involved amputation of right hand fingers of a contract worker while fixing blade in band-saw machine.

1.5.2 RAPP-7&8

In December 2023, a fatal accident occurred at RAPP-7&8 involving a contract worker who fell from a scaffolding walkway at a height of approximately 13 meters. The worker was engaged in the task of removing shuttering material erected for constructing the fill structure of RAPP-8 Natural Draft Cooling Tower (NDCT). AERB identified the root cause of the accident as a failure to anticipate hazards related to material handling at height and the arrangement of scaffolding. AERB also acknowledged the corrective actions taken by the site to enhance the safety of the scaffolding in the NDCT area and improve work procedures. The recommendations made by AERB were implemented at the site, and an action taken report was submitted.

There were no reportable accidents at KAPP-3&4, KAIGA-5&6, GHAVP-1&2, NFC-Kota and PFBR during the period.

1.6 Operating Nuclear Power Plants, Research Reactors, Fuel Cycle Facilities and Industrial Facilities

AERB continued to carry out safety review & surveillance of operating Nuclear Power Plants, Research Reactors, Fuel Cycle Facilities and Industrial Facilities under its purview. Safety reviews of application for renewal of licence for operation, safety proposals submitted by these facilities and resolution of other safety issues that would emanate during plant operation is carried out. AERB renews Licence for operation of NPPs under the Atomic Energy Act, 1962 (and rules framed there under), the Factories Act, 1948 (and rules framed there under) and issues Authorization for safe disposal / transfer of radioactive waste under the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 (GSR-125) based on satisfactory safety review. Important licenses / authorizations / permissions / clearances issued during 2023 are as follows:

- Renewal of license for operation of KGS-3&4 up to April 30, 2028.
- Renewal of license for operation of NAPS-1&2 up to June 30, 2028.
- Renewal of license for operation of FBTR & IFSB up to June 30, 2028.
- Renewal of license for operation of CORAL, IGCAR up to August 31, 2028.
- Renewal of license for operation of RML, IGCAR, up to December, 2028.
- Renewal of license for operation of RCL, IGCAR up to December, 2028.
- Renewal of license for operation of Jaduguda mine up to January 31, 2028.
- Renewal of license for operation of Tummalapalle mine up to February 29, 2028.

- Renewal of license for operation of Narwapahar mine up to March 31, 2028.
- Renewal of license for operation of Bhatin mine up to April 30, 2028.
- Renewal of license for operation of Turamdih mine up to December 31, 2028.
- Renewal of license for operation of Rare Earths Division (RED), IREL (India) Ltd. Udyogamandal up to November 30, 2028
- Renewal of licence for operation of HWP-Hazira up to July 31, 2028.
- Extension of validity of the license for operation of HWP-Tuticorin up to July 31, 2025.
- Extension of validity of the siting & construction consent for Magnesium Recycling Technology Development & Demonstration Facility (MRTDDF) at Zirconium Complex up to March 31, 2026
- Consent for commissioning of Solvent Production Plant (SPP) at HWP-Tuticorin
- Consent for siting & construction of Versatile Deuterated compounds Production Plant (VDPP) at HWBF-Vadodara

1.7 Operating Nuclear Power Plants and Research Reactors

22 NPPs are under operation. The details are as follows.

Table 1.4: List of Operating NPPs

Operating NPPs	Site/district /State	Unit	Type	Gross Capacity (MWe)	Commencement of Commercial Operation	Validity of License
Nuclear Power Plants (NPPs						
Tarapur Atomic Power Station	Tarapur / Palghar / Maharashtra	TAPS-1#	BWR	160	October – 1969	March 2026
		TAPS-2#		160		
		TAPS-3	PHWR	540	August – 2006	August 2026
		TAPS-4		540	September-2005	
Rajasthan Atomic Power Station	Rawatbhata / Chittorgarh / Rajasthan	RAPS-1##	PHWR	100	December-1973	August 2024
		RAPS-2		200	April-1981	
		RAPS-3###		220	June-2000	October 2027
		RAPS-4		220	December-2000	
		RAPS-5		220	February-2010	March 2025
		RAPS-6		220	March-2010	
Kakrapar Atomic Power Station	Kakrapar / Tapi / Gujarat	KAPS-1	PHWR	220	May-1993	July 2024
		KAPS-2		220	September-1995	
Madras Atomic Power Station	Kalpakkam / Kancheepuram / Tamil Nadu	MAPS-1####	PHWR	220	January-1984	December 2025
		MAPS-2		220	March-1986	

Operating NPPs	Site/district /State	Unit	Type	Gross Capacity (MWe)	Commencement of Commercial Operation	Validity of License
Narora Atomic Power Station	Narora / Bulandshahar / Uttar Pradesh	NAPS-1	PHWR	220	January-1991	June 2028
		NAPS-2		220	July-1992	
Kaiga Atomic Power Station	Kaiga / Uttar Kannada / Karnataka	KGS-1	PHWR	220	November-2000	May 2027
		KGS-2		220	March-2000	
		KGS-3		220	May-2007	April 2028
		KGS-4		220	January-2011	
Kudankulam Nuclear Power Plant	Kudankulam / Tirunelveli / Tamil Nadu	KKNPP-1	PWR	1000	December-2014	July 2025
		KKNPP-2		1000	December-2017	

TAPS 1&2 Units are under shutdown since 2020 for Primary Coolant pipeline replacement

RAPS-1 Unit is under shutdown since 2004 and the reactor core is defueled

###RAPS-3 Unit is under shutdown since 2022 for EMCCR activities

####MAPS-1 Unit is under shutdown since 2018 due to leak from pressure tubes and calandria side tube sheet of North End Shield

Number of meetings of Safety Committees / Standing Committees / Expert Groups conducted during the year 2023 are given in table 1.5.

Table 1.5: Meetings of Safety Committees / Standing Committees / Expert Groups

Name of the Committee / Expert Group	No. of meetings
Safety Review Committee for Operating Plants (SARCOP)	12
LWR Safety Committee (TAPS-1&2 & KK-1&2)	12
PHWR Safety Committee -1 (RAPS-1&2, MAPS-1&2, NAPS & KAPS-1&2)	16
PHWR Safety Committee-2 (KGS-1&2, KGS-3&4, RAPS-3&4 & RAPS-5&6)	12
PHWR Safety Committee -3 (TAPS-3&4)	3
IGCAR Safety Committee (FBTR, CORAL, KAMINI, IFSB, RML & RCL)	8
Standing Committee on Control, Instrumentation & Computer Based Systems (SCCI & CS)	3
Expert Group on Coolant Channels (EGCC)	8
CRNRE for Review of INES Ratings of Events	4
Total	**78**


Glimpses of SARCOP Meeting at TAPS-1&2

1.7.1 Tarapur Atomic Power Station 1 to 4

TAPS-1 & TAPS-2 are under shutdown since January 08, 2020 and July 13, 2020 respectively for replacement of Class-I piping vulnerable to Inter-Granular Stress Corrosion Cracking (IGSCC). Both units of TAPS-3&4 were operational in the year 2023.

1.7.2 Rajasthan Atomic Power Station - 1 to 6

RAPS-2, RAPS-4, RAPS-5&6 were operational in the year 2023. RAPS-1 is under shut down since October 2004 and reactor core is defueled. RAPS-3 is under shutdown since October 27, 2022 for En-masse Coolant Channel Replacement (EMCCR) and En-masse Feeder Replacement (EMFR). In RAPS-3, installation and Pre-Service Inspections (PSI) of newly installed coolant channels has been completed.

1.7.3 Kakrapar Atomic Power Station – 1&2

KAPS-1&2 operated safely in the year 2023.

1.7.4 Madras Atomic Power Station -1&2

MAPS-1 is under shutdown since January 30, 2018 due to leak from pressure tubes O-09 & Q-09 and North End Shield. The Root Cause Analysis (RCA) reports for pressure tube and end shield leaks submitted by NPCIL are under review in AERB. MAPS-2 was operational in the year 2023.

1.7.5 Narora Atomic Power Station – 1&2

NAPS-1&2 operated safely in the year 2023.

NAPS-1&2 underwent Periodic Safety Review (PSR) as a pre-requisite for renewal of its operating licence beyond June 30, 2023 under 'The Atomic Energy Act, 1962' (and rules framed thereunder). Station had also submitted application for renewal of licence for operation under The Factories Act, 1948 (and rules framed thereunder) and authorization for radioactive waste disposal/ transfer under the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 (GSR-125).

These applications were reviewed by AERB following multi-tier review process. Review assessment indicated that the performance of NAPS-1&2 with respect to nuclear, radiological and industrial safety had been satisfactory. Radioactive effluent discharges were well below the limits specified in technical specifications for operation. Effective dose to a member of public residing at exclusion zone had been well within the limit prescribed by AERB. Station had implemented all short & medium-term safety upgrades identified based on review of Fukushima NPP accident. Implementation of long term safety upgrades are in progress. Based on satisfactory review, AERB renewed the licenses for next 5 years i.e. up to June 30, 2028.

1.7.6 Kaiga Generating Station (KGS) - 1 to 4

KGS-1 to 4 operated safely in the year 2023.

KGS-3&4 underwent Limited Scope Safety Review (LSSR) as a pre-requisite for renewal of its operating licence beyond April 30, 2023 under 'The Atomic Energy Act, 1962 (and rules framed there under)'. Station had also submitted application for renewal of licence for operation under The Factories Act, 1948 (and rules framed there under) and authorization for radioactive waste disposal/transfer under the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 (GSR-125).

These applications were reviewed by AERB following multi-tier review process. Review assessment indicated that the performance of KGS-3&4 with respect to nuclear, radiological and industrial safety had been satisfactory. Radioactive effluent discharges were well below the limits specified in technical specifications for operation. Effective dose to a member of public residing at exclusion zone had been well within the limit prescribed by AERB. Station had implemented all short & medium-term safety upgrades identified based on review of Fukushima NPP accident. Implementation of long term safety upgrades are in progress. Based on satisfactory review, AERB renewed the licenses for next 5 years i.e. up to April 30, 2028.

1.7.7 Kudankulam Nuclear Power Plant -1&2

KKNPP-1&2 operated safely in the year 2023.

1.8 Status of Implementation of Safety Enhancements at Operating NPPs

The safety enhancements identified for Indian NPPs subsequent to the accident at Fukushima Daiichi NPPs were classified as short term, medium term and long term. Implementation of the short term and medium term safety enhancements have been completed. The long-term enhancements include enhancing severe accident management programme, strengthening hydrogen management provisions, provision of Containment Filtered Venting Systems (CFVS) and creation of On-Site Emergency Support Centre (OESC). The required R&D efforts, analyses, detailed engineering and testing/qualification, for these systems have been completed, and their on-site implementation is now in progress. The present status of long-term safety upgrades/ measures is as follows:

1.8.1 Accident Management Programme

The Accident Management Guidelines for different NPP designs (PHWR, BWR & PWR) were developed based on technical bases reviewed and accepted by AERB. These guidelines have been established at all the operating NPPs, including implementation of the necessary hardware enhancements, training of the operating personnel, mock-ups and periodic surveillance.

1.8.2 Strengthening Hydrogen Management Provisions

The hydrogen management provision in Indian PHWRs includes installation of Passive Catalytic Recombiner Devices (PCRDs) along with provisions for homogenizing the containment atmosphere and maintenance of the inert steam atmosphere. Installation of PCRDs have been completed at all stations. Remaining activities are in progress.

1.8.3 Provision of Containment Filtered Venting System (CFVS)

Technology development of CFVS has been completed and detailed engineering of the system has been finalized after analysis and testing. CFVS has been installed in TAPS-1&2 (BWR). Installation of CFVS at other operating NPPs where the requirement has been envisaged, is in progress.

1.8.4 On-Site Emergency Support Centre (OESC)

On-site Emergency Support Centre (OESC) is being set up at all the NPP sites. AERB has framed requirements and guidelines for establishing OESCs at all NPPs, which takes into account the NPPs at the given site and the accident scenarios. After AERB's review and permission, construction of OESC at TAPS, KAPS, MAPS, KGS and RAPS sites is in progress.

1.9 Fast Breeder Test Reactor (FBTR), IGCAR

FBTR underwent Periodic Safety Review (PSR) as a pre-requisite for renewal of its operating licence beyond June 30, 2023 under The Atomic Energy Act, 1962 (and rules framed there under). FBTR had also submitted application for renewal of authorization for radioactive waste disposal/ transfer under the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 (GSR-125). These applications were reviewed by AERB following multi-tier review process. Review assessment indicated that the performance of FBTR with respect to nuclear, radiological and industrial safety had been satisfactory. Radioactive effluent discharges remained well below the limits specified in technical specifications for operation. Effective dose to a member of public residing at exclusion zone had been well within the limit prescribed by AERB. FBTR has implemented all short & medium-term safety upgrades identified based on review of Fukushima NPP accident and actions are in progress for implementation of remaining upgrades. Based on the assessment of station applications, AERB renewed the licenses for next 5 years i.e. up to June 30, 2028.

Based on satisfactory review, AERB granted permission for commencement of 32nd irradiation campaign of FBTR with its design power level of 40 MWth. The irradiation campaign was completed in September, 2023.

1.10 KAMINI Reactor, IGCAR

During the year, KAMINI reactor was operated as per the user requirements.

1.11 Licensing of Operating Staff at NPPs and RRs

Operating personnel of NPPs namely Shift Charge Engineer (SCE), Assistant Shift Charge Engineer (ASCE) and Control Engineer (CE) are required to go through a rigorous licensing/relicensing process.

During the year 2023, total 26 meetings were held for licensing/re-licensing of operating personnel responsible for operations at various operating NPPs. A total of 187 candidates were licensed / relicensed. In addition to the above, 5 personnel for FBTR operation were also licensed / re-licensed. Details of manpower licensing of operating NPPs are given in Table 1.6.

Table 1.6: Licensing of Operating Staff

Plants	No. of Persons Licensed					Licensing Committee Meetings
	SCE	ASCE	ASCE (F)	CE	CE (F)	
TAPS-1&2	-	1	-	1	-	1
TAPS 3&4	7	9	1	8	3	3
RAPS-1&2	1	5	5	-	1	2
RAPS-3&4	6	6	2	9	-	3
RAPS-5&6	4	6	5	6	1	4
MAPS-1&2	8	4	2	7	-	2
NAPS-1&2	5	5	1	10	4	2
KAPS-1&2	2	2	2	6	4	2
KGS-1&2	1	4	3	-	-	2
KGS-3&4	2	4	-	2	1	2
KKNPP-1&2	5	4	-	12	-	3
Total	**41**	**50**	**21**	**61**	**14**	**26**

1.12 Nuclear Fuel Cycle Facilities and Industrial Facilities

The nuclear fuel cycle facilities and other related industrial facilities of DAE under the regulatory control of AERB are mines and ore processing plants of Uranium Corporation of India Ltd. (UCIL), mineral separation plants and chemical processing plants of Indian Rare Earths Limited (IREL), Nuclear Fuel Complex (NFC), Zirconium Complex (ZC), Heavy Water Board Facilities (HWBF) / Heavy Water Plants (HWP), Electronic Corporation of Indian Ltd. (ECIL) and some of the facilities of Indira Gandhi Centre for Atomic Research (IGCAR). In addition to this, Beach Sand Minerals (BSM) and other facilities handling Naturally Occurring Radioactive Materials (NORM) are also regulated by AERB with respect to radiological safety aspects. The list of fuel cycle facilities is given in Table 1.7.

Table 1.7: Status of Nuclear Fuel Cycle Facilities and other Industrial Facilities

Type of Facility	Name	Functional Status	District/ State	Scope of the Facility	Validity of Current License
Facilities Operated by UCIL					
Mines	Narwapahar Mine	In operation	Singhbhum (E) / Jharkhand	Underground Uranium Mine	March 31, 2028
	Turamdih Mine	In operation	Singhbhum (E) / Jharkhand	Underground Uranium Mine	December 31, 2028
	Bagjata Mine	In operation	Singhbhum (E) / Jharkhand	Underground Uranium Mine	June 30, 2025
	Mohuldih Mine	In operation	Singhbhum (E) / Jharkhand	Underground Uranium Mine	October 31, 2024
	Jaduguda Mine	Shutdown	Singhbhum (E) / Jharkhand	Underground Uranium Mine	January 31, 2028
	Bhatin Mine	Shutdown	Singhbhum (E) / Jharkhand	Underground Uranium Mine	April 30, 2028
	Banduhurang Mine	In operation	Singhbhum (E) / Jharkhand	Opencast Uranium Mine	June 30, 2026
	Tummalapalle Mine	In operation	Y.S.R. Kadapa (Dist) / Andhra Pradesh	Underground Uranium Mine	February 29, 2028
Mills	Jaduguda Mill	In operation	Singhbhum (E) / Jharkhand	Uranium Ore Processing	December 31, 2025
	Turamdih Mill	In operation	Singhbhum (E) / Jharkhand	Uranium Ore Processing	February 28, 2026
	Tummalapalle Mill	In operation	Y.S.R. Kadapa (Dist) / Andhra Pradesh	Uranium Ore Processing	June 30, 2027
Facilities Operated by IREL (India) Ltd.					
Mines	Chavara	In operation	Kollam (Dist) / Kerala	Mineral Separation	August 31, 2024

Type of Facility	Name	Functional Status	District/ State	Scope of the Facility	Validity of Current License
	Manavalakurichi	In operation	Kanyakumari (Dist) / Tamilnadu	Mineral Separation	August 31, 2024
	OSCOM Chatrapur	In operation	Ganjam (Dist) / Odisha	Mineral Separation	August 31, 2024
Ore Processing Facilities	OSCOM, Chatrapur	In operation	Ganjam (Dist) / Odisha	Monazite Processing	April 30, 2025
Others	Udyogamandal	In operation	Ernakulam (Dist) / Kerala	Rare Earths Compounds and Uranium Production	November 30, 2028
Facilities Operated by ECIL					
Electronics Manufacturing	Electronics Corporation of India Limited (ECIL), Hyderabad	In operation	Telangana	Electronics Manufacturing	June 30, 2025
	ECIL, Tirupathi	In operation	Andhra Pradesh	Electronics Manufacturing	October 31, 2026
Facilities Operated by NFC					
Nuclear Fuel Fabrication Facilities	NFC Hyderabad	In operation	Hyderabad / Telangana	Fuel Fabrication	August 31, 2027
	Zirconium Complex, Pazhayakayal	In operation	Tuticorin / Tamil Nadu	Reactor Grade Zirconium Sponge Production	June 30, 2026

Type of Facility	Name	Functional Status	District/ State	Scope of the Facility	Validity of Current License
Facilities Operated by HWB					
Heavy Water Plants	HWP-Kota, Rawatbhatha	In operation	Rawatbhata/ Chittorgarh Dist/ Rajasthan	Heavy Water Production	December 31, 2025
	HWP-Manuguru	In operation	Telangana State	Heavy Water Production Other diversified Activities viz. Production of Enriched Boric Acid, Elemental Boron, Boron Carbide Pellets and O-18 Enriched Water	June 30, 2025
	HWBF-Vadodara	Heavy Water Production Suspended Solvent & K & Na Metal Plant are in operation	Baroda / Gujarat	Tributyl Phosphate, Potassium & Sodium Metal Production	May 31, 2026
	HWP-Hazira	In operation	Hazira / Surat / Gujarat	Heavy Water Production	July 31, 2028
	HWP-Thal	In operation	Raigad / Maharashtra	Heavy Water Production	December 31, 2024
	HWP-Tuticorin	Heavy Water Production Suspended. Diversified Activities Like Solvent Production Plant in operation	Tuticorin / Tamil Nadu	Production of Solvents: TiAP, DHOA, D2EHPA-II	July 31, 2025

Type of Facility	Name	Functional Status	District/ State	Scope of the Facility	Validity of Current License
	HWBF-Talcher	Heavy Water Production Suspended. Diversified Activities Like Solvent Production Plant in operation	Talcher / Angul Dist. / Odisha	Production of Solvents: TBP, ^{10}B Enriched Boron, D2EHPA, TOPO, TAPO, DNPPA and other Products viz. ^{10}B Enriched Boron, Boric Acid	August 31, 2025
	HWBF-Mumbai (formally known as TDP-Chembur)	Main Plant Operation is Shut down (However, different Systems are being operated in Closed Loop for Developmental Activities)	Mumbai/ Maharashtra	Crude Sodium Di-Uranate Production	October 31, 2026

Number of meetings conducted by various safety committees for fuel cycle facilities and other industrial facilities during this period is given Table 1.8.

Table 1.8: Meeting of Safety Review Committee of Fuel Cycle Facilities

Name of the Committee	No. of meetings
NFSC-1 (UCIL-AMD Safety Committee and BSM-NORM Safety Committee)	6
NFSC-2 (NFC Safety Committee and ECIL Safety Committee)	4
NFSC-3 (HWP Safety Committee)	3
Industrial and Fire Safety Committee (I & FSC)	2
Occupational Health Safety Committee (OHSC)	1

1.12.1 Uranium Mines and Mills of UCIL

During the year, the licence for operation issued under 'The Atomic Energy Act, 1962 (and rules framed there under) & authorization for radioactive waste disposal / transfer under GSR-125 of Jaduguda mine, Tummalapalle mine, Narwapahar mine, Bhatin mine and Turamdih mine were due for renewal. The applications submitted by UCIL for renewal of the licenses / authorizations were reviewed in AERB following multi-tier review process. Safety assessment indicated that operational & radiological status of these mines was satisfactory. The average individual doses to the mine workers were well within the regulatory limit. Radioactive waste discharged/transferred from these mines remained within AERB authorized limits. The average radon concentration and gamma dose rate were within the permissible limit. Based on satisfactory review, AERB renewed the licence with respect to radiation safety for Narwapahar mine, Turamdih mine, Jaduguda mine, Bhatin mine and Tummalapalle mine for next five years.

1.12.2 Beach Sand Mines & Mills of IREL (India) Ltd.

Rare Earth Division (RED) of IREL (India) Ltd., Udyogamandal and Mineral Separation Plants (MSP) of IREL (India) Ltd at Chavara, Manavalakurichi and Chatrapur operated safely during the year. Monazite up-gradation plants at IREL (India) Ltd, Orissa Sand Complex (OSCOM), Manavalakurichi and Chavara were operational.

Application submitted by IREL for renewal of these license / authorization were reviewed in AERB following multi-tier review approach. Review indicated that during the license period, performance of the IREL facilities with respect to radiological and industrial safety had been satisfactory. Facility operated within the licensed capacity without any major operational problems. Radioactive effluent discharges from facilities were well within the technical specification / authorized limits. Environmental monitoring has not indicated any adverse impact of the facility operation on the environment. Based on satisfactory review, AERB renewed the license for operation & authorization for disposal / transfer of radioactive waste of IREL, Udyogamandal for next five years i.e. up to November 30, 2028.

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

All the plants of NFC, Hyderabad and ZC, Pazhayakayal operated safely during the year.
Consent for Siting & Construction of Magnesium Recycling Technology Development & Demonstration Facility (MRTDDF) at Zirconium Complex (ZC), Pazhayakayal was valid up to March 31, 2023. ZC submitted application for extension of validity of Consent for Siting & Construction of MRTDDF due to delay in tendering process. Based on satisfactory review, AERB extended the validity of consent for siting & construction of MRTDDF up to March 31, 2026.

1.12.4 Heavy Water Board Facilities (HWBF)

Heavy water plants at Kota, Manuguru, Thal and Hazira were operational. Heavy water production plant at Talcher was dismantled. Dismantling of heavy water production plant at Vadodara is under progress. Heavy water production facility at Tuticorin has been declared as 'CLOSED'. Diversifed activities at HWBF-Vadodara, HWBF-Talcher and HWP-Tuticorin were operational. Technology Demonstration Plant (TDP), Chembur is under shutdown due to non-availability of phosphoric acid from fertilizer plant. However, trial operation for developmental activities were carried out as and when required. During the year following License applications were reviewed:

a) Renewal of Licence for Operation of HWP-Hazira

Application submitted for renewal of license for operation was reviewed in AERB following multi-tier review process. Safety review indicated that during the existing Licence period, the performance of the facility had been satisfactory. Based on the satisfactory review, AERB renewed the Licence for operation of HWP-Hazira for a period of five years i.e. up to July 31, 2028.

b) Extension of Validity of Existing License for Operation of HWP- Tuticorin

HWP-Tuticorin submitted application for extending validity of exisiting License for operation of HWP-Tuticorin (main plant & Versatile Solvent Synthesis Plant (VSSP)) for a period of two years i.e. up to July 31, 2025 in view of some more time required for revamping of the main plant. Based on satisfactory review, AERB extended the validity of existing license for operation of main plant and VSSP at HWP-Tuticorin for a period of two years i.e. up to July 31, 2025.

c) Consent for Commissioning of Solvent Production Plant (SPP) at HWP-Tuticorin

HWB is in process to set-up an industrial scale plant namely Solvent Production Plant (SPP) in the existing premises of HWP-Tuticorin for production of solvent viz. Tri Butyl Phosphate (TBP), Mono Ester of 2-Ethyl Hexyl Phosphoric Acid (D2EHPA-II), Tri Octyl Phosphine Oxide (TOPO), Tri iso Amyl Phosphate (TiAP) and Di Hexyl Octanamide (DHOA). After completion of construction & installation of all major equipment, HWP-Tuticorin has submitted application for commissioning of SPP. This application was reviewed in AERB following multi-tier review process. Based on review, AERB granted consent for commissioning of SPP for production of solvent TBP, D2EHPA-II & TOPO.

d) Consent for Siting & Construction Of Versatile Deuterated Compounds Production Plant at HWBF-Vadodra

HWBF-Vadodra submitted the application for siting & construction of Versatile Deuterated Compounds Production Plant. This application was reviewed in AERB following multi-tier review process. Based on the satisfactory review, AERB granted consent for siting & construction of Versatile Deuterated Compounds Production Plant.

1.12.5 Licensing of Operating Staff at Heavy Water Plants

During the year 2023, total 5 meetings were held for licensing/re-licensing of operating personnel

Table 1.9: Licensed Operating Staff of HWP

Plants	No. of Persons Licensed	Licensing Committee Meetings
HWP (Kota)	5	1
HWP (Manuguru)	10	2
HWP (Thal)	4	1
HWP (Hazira)	9	1

responsible for operations at various operating heavy water plants. A total of 28 candidates were licensed / relicensed. Details of manpower licensing of operating heavy water plants are given in Table 1.9.

1.12.6 Electronics Corporation of India Limited

ECIL facilities at Hyderabad and Tirupati operated safely during the year.

1.12.7 IGCAR Facilities

a) Demonstration Fast Reactor Fuel Reprocessing Plant (DFRP), IGCAR

AERB had earlier granted permission for cold commissioning with Uranium (U) for DFRP. After completion of cold commissioning, DFRP submitted application for carrying out limited hot runs with Plutonium (Pu) to AERB. The application was reviewed in AERB and DFRP was asked to submit additional supporting documents for further review. Currently these submissions are under review in AERB. Meanwhile, on request of IGCAR, AERB permitted DFRP to continue with Uranium run using Natural Uranium pins.

b) CORAL (Compact Reprocessing of Advanced Fuels in Lead cells), IGCAR

CORAL operated safely during the year as per the requirements.

CORAL submitted applications for renewal of license for operation and authorization for safe disposal / transfer of radioactive waste to AERB. These applications were reviewed in AERB following multi-tier review approach. Based on satisfactory review, AERB renewed the license for operation and authorization for safe disposal / transfer of radioactive waste of CORAL for five years i.e. up to August 31, 2028.

c) Radio Metallurgical Laboratory (RML), IGCAR

RML operated safely during the year as per the requirements

IGCAR applications for renewal of license for operation of Radio-Metallurgy Laboratory (RML) under 'The Atomic Energy Act, 1962 (and rules framed thereunder) and authorization for safe disposal / transfer of radioactive wastes under GSR 125 to AERB. The applications were reviewed in AERB following multitier review approach. Based on satisfactory review, AERB renewed the license for operation and authorization for safe disposal / transfer of radioactive wastes of RML, IGCAR for next five years i.e. up to December 31, 2028.

d) Radio Chemistry Laboratory (RCL), IGCAR

RCL operated safely during the year as per the requirements

IGCAR submitted applications for renewal of license for operation of Radio Chemistry Laboratory (RCL), under 'The Atomic Energy Act, 1962 (and rules framed thereunder) and authorization for safe disposal / transfer of radioactive wastes under GSR-125 to AERB. These applications were reviewed in AERB following multitier review approach. Based on satisfactory review, AERB renewed the license for operation and authorization for safe disposal / transfer of radioactive wastes of RCL, IGCAR for next five years i.e. up to December 31, 2028.

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

Presently, with the amendment of Atomic Minerals Concession Rules, 2016, only Central Government or its units are vested with the rights to mine beach sand minerals and the mining leases of all existing private companies have been prematurely terminated by Ministry of Mines. AERB has also not renewed the licence for operation of mineral separation plants by private entities under Atomic Energy (Radiation Protection) Rules, 2004. However, in view of stockpiled monazite enriched tailings in few of these facilities, AERB has been approving the designation of Radiological Safety Officer (RSO) in these facilities so as to ensure the radiation surveillance of the plant premises. Periodic radiological reports submitted by the Beach Sand Mines (BSM) facilities were reviewed and no abnormality was observed by AERB.

1.13 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 AERB are divided into two categories, termed as,

(a) Events (b) Significant Events

This categorization of events is done based on their safety significance and importance to operational safety experience feedback. Based on established reporting criteria, Event Reports (ER) and Significant Event Reports (SER) are submitted to AERB. The SERs received from 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-1.1 below.

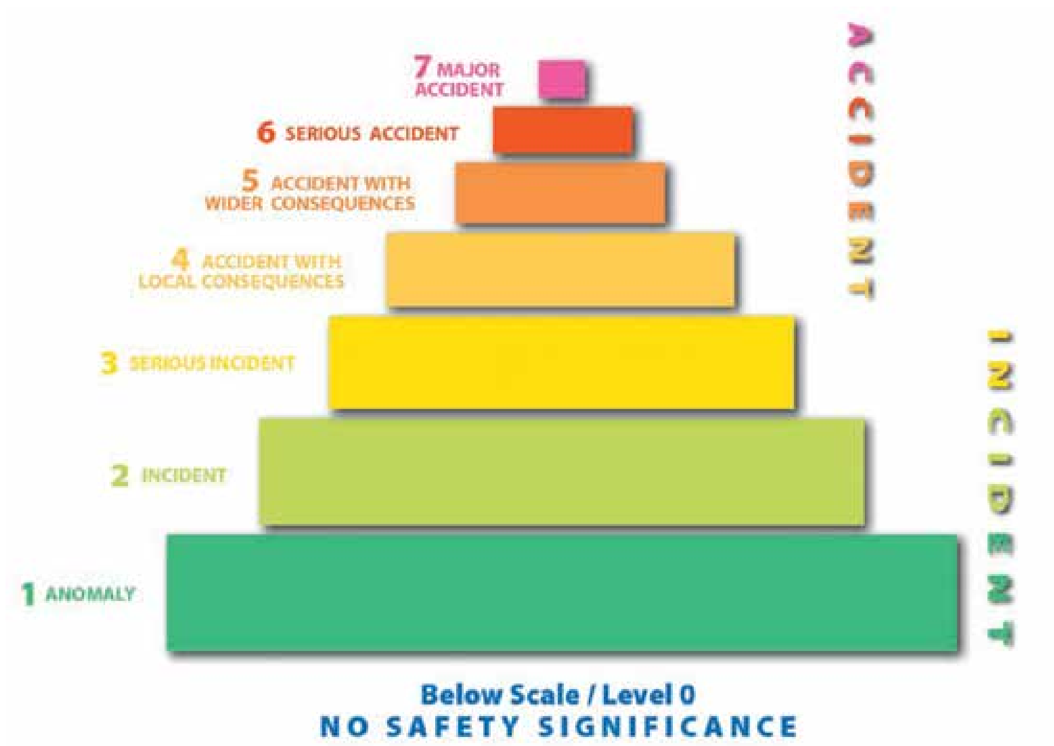


Figure-1.1: International Nuclear & Radiological Event Scale

Events rated at level 4 and above are termed as 'Accidents'. Events rated at levels 1, 2 and 3 are called 'Incidents'. The level 0 or below scale means events that have no nuclear and radiological safety significance.

1.13.1 Significant Events in NPPs under Commissioning

During the year 2023, one significant event was reported from KAPP-3 during Phase-C commissioning. While KAPP-3 reactor was in hot shutdown state, Secondary Shutdown Sytem (SDS-2) actuated due to control power supply disturbance. On investigation it was found that moisture ingress from the leaked steam led to failure of power supplies and resulted in SDS-2 actuation. On investigation steam leak was found from Steam Generator-4 main feed water line strainer due to improper venting of trapped air during system maintenance.

The event was reviewed in detail by AERB and plant was recommended to enhance the sensitization of O&M personnel towards procedure adherence to prevent reoccurrence of such event. The event was rated at 'Level 0' on INES.

1.13.2 Significant Events in NPPs under Operation

During the year 2023, a total of 21 significant events were reported from operating NPPs. Out of these 21 events one significant event at MAPS-1&2 was related to industrial safety and hence it was not rated on INES. Out of the remaining 20 events, 19 events were rated at 'Level 0' on INES, while one event at KKNPP-1 was assigned provisional rating of Level-1 on INES.

Leak from a QBIS Tank Vent Line Connection in KKNPP-1

On August 20, 2023, when KKNPP-1 was operating at full power, a disturbance in feed water flow occurred causing steam generator level low. Low levels in steam generator resulted in tripping of three primary circulating pumps as per logic. Reactor tripped on 'more than 2 primary circulating pumps unavailable' trip parameter. Subsequently, remaining fourth primary circulating pump also tripped on SG low level. Reactor was brought to hot shut down state. Core cooling was ensured through natural circulation. The cause of loss of feed water flow to SGs was attributed to a malfunction of controller of feed pump.

During hot leak search conducted after reactor trip, minor leak was observed from weld joint of liquid poison injection tank vent line connection to pressurizer spray header nozzle. A crack of 3 mm length was observed at 2-3 O'clock position. The crack had occurred in an area which was not protected by thermal shield. Other poison tank vent line connection to the nozzle on pressurizer spray header were found normal and no deterioration was observed. The root cause analysis of the cracking in nozzle based on metallographic analysis is under progress.

The number of SERs in operating NPPs along with their ratings on INES are given in Table-1.10.

Table 1.10: Number of Significant Events in Operating NPPs reported in Year 2023

Operating NPPs	INES Rating of Events	
	INES-0	INES-1
TAPS-1 & 2	0	0
TAPS-3 & 4	2	0
RAPS-1 & 2	3	0
RAPS-3 & 4	2	0

Operating NPPs	INES Rating of Events	
	INES-0	INES-1
RAPS-5 & 6	0	0
MAPS-1 & 2	2	0
NAPS-1 & 2*	3	0
KAPS-1 & 2	3	0
KGS-1 & 2	3	0
KGS- 3 & 4	0	0
KKNPP-1 & 2*	1	1
Total	19	1

* One event each at KKNPP-1 and NAPS-1 are assigned provisional INES rating of Level 1 and 0 respectively since these are under review.

For the purpose of analysis, the events reported in year 2023 were categorized as per the IAEA-IRS coding system. The classification of systems failed / affected during the significant events is given in Figure-1.2. The classification of direct causes and root causes of the significant events are given in Figure-1.3 & 1.4 respectively.

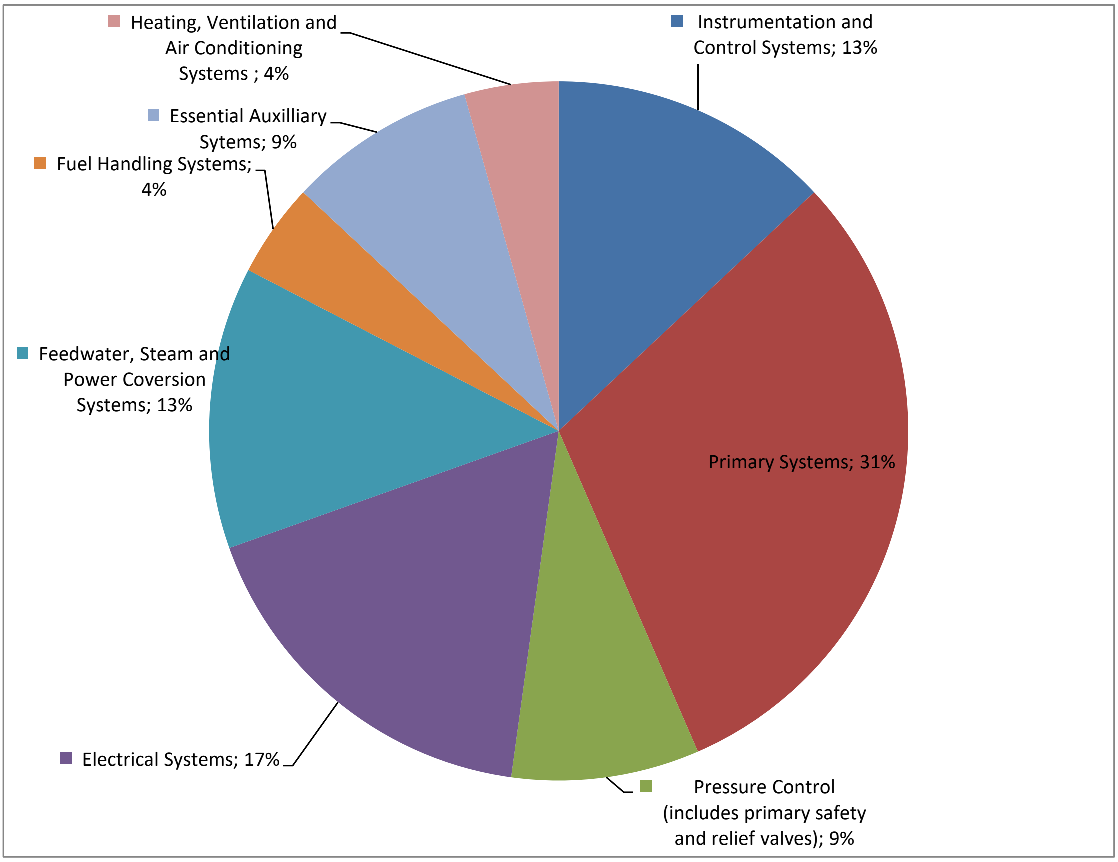


Figure-1.2: Classification of Failed/Affected System of SERs

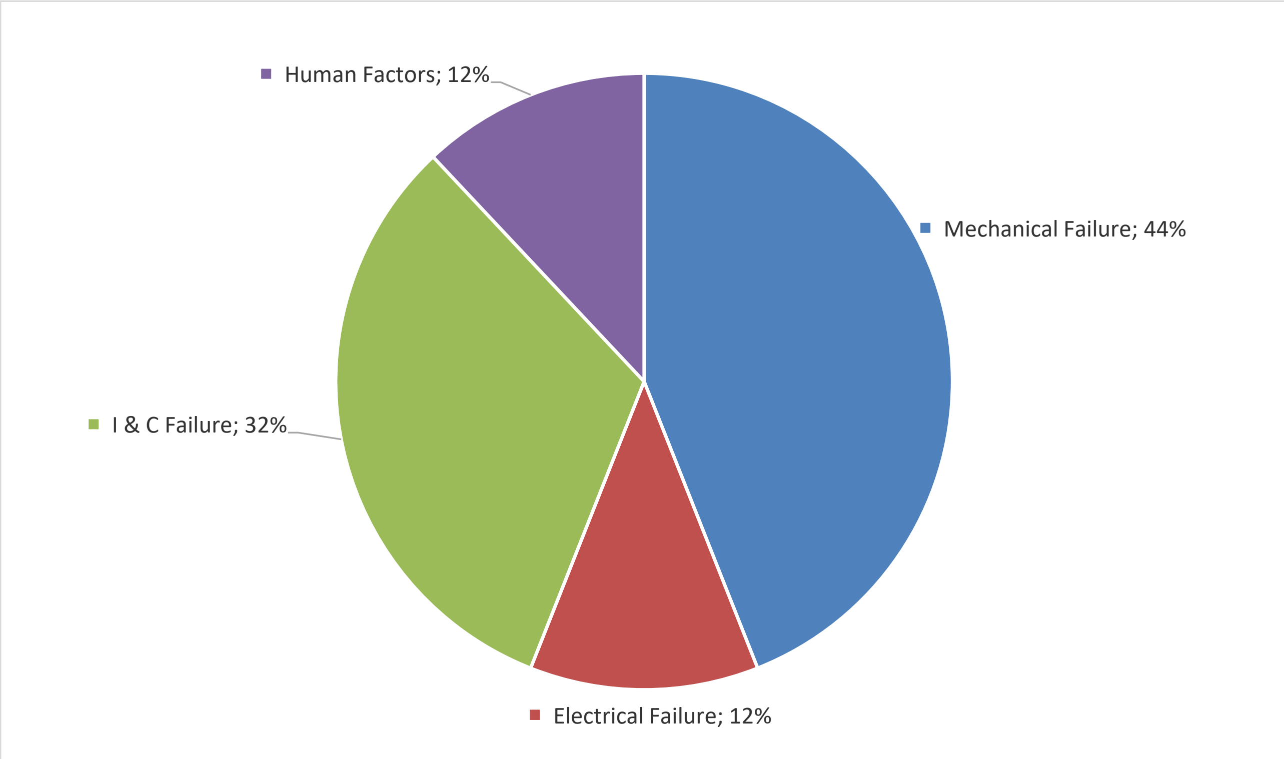


Figure-1.3: Classification of Direct Causes of SERs

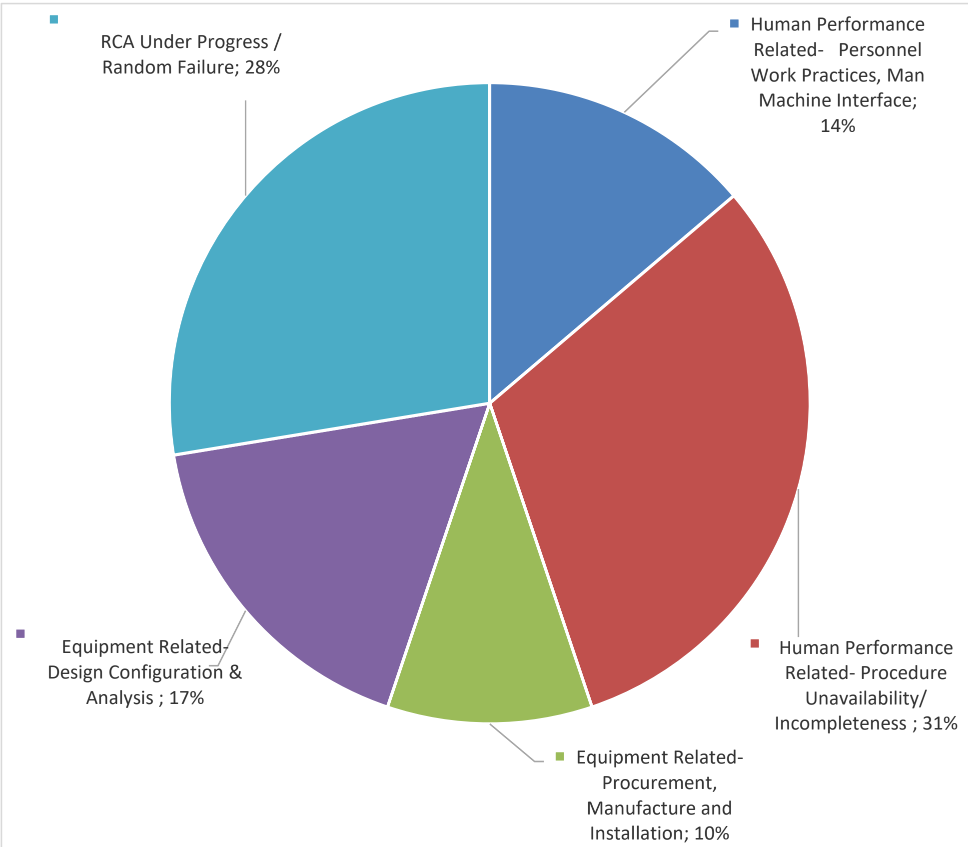


Figure-1.4: Classification of Root Causes of SERs

1.14 Occupational Injury Statistics of DAE Units

Occupational Injury Statistics for the year 2022 for DAE units (other than BARC facilities, AMD and mines of IREL & UCIL) was analysed. During the year 2022, there were 30 reportable injuries and 2 fatal injuries incurring a loss of 14,622 man-days. In Year 2022, Frequency Rate (FR), Severity Rate (SR), Injury Index (II) & Incidence Rate (IR) were 0.19, 94.67, 0.018 & 0.50 respectively. There was no notifiable disease reported during the period from any of the operating units of DAE.

Details are presented in table and Year-wise Frequency Rate (FR), Severity Rate (SR), Injury Index (II) and Incidence Rate (IR) in DAE Units are shown in Figure 1.5, 1.6, 1.7 and 1.8 respectively.

Table 1.11: Unit wise Comparison of Reportable Occupational Injuries in DAE Units for the Year 2022

Unit	C1 No. of Lost Time (Reportable) Injury	C2 No. of Man-days Lost	C3 No. of Fatal Injury	C4 No. of Employees	C5 No. of Man-hours Worked	C6 Frequency Rate $\frac{C1 \times 10^6}{C5}$	C7 Severity Rate $\frac{C2 \times 10^6}{C5}$	C8 Injury Index $\frac{C6 \times C7}{1000}$	C9 Incidence Rate $\frac{C1 \times 10^3}{C4}$
NP Plants	2	6015	1	15955	37285708	0.05	161.32	0.009	0.13
NP Projects	7	1382	0	19189	57897150	0.12	22.71	0.003	0.36
HWB	6	482	0	4208	10838867	0.55	44.47	0.025	1.43
IREL	0	0	0	563	1358340	0.00	0.00	0.000	0.00
NFC & ZC	5	521	0	6250	16983647	0.29	30.68	0.009	0.80
UCIL	6	6160	1	2831	5783032	1.04	1065.19	1.105	2.12
ECIL	1	35	0	4548	10808328	0.09	3.24	0.000	0.22
IGCAR	1	10	0	3369	6978714	0.14	1.43	0.000	0.30
BRIT	0	0	0	958	1024080	0.00	0.00	0.000	0.00
VECC	1	6	0	1047	2080000	0.48	2.88	0.001	0.95
RRCAT	1	11	0	1673	3408688	0.29	3.23	0.001	0.60

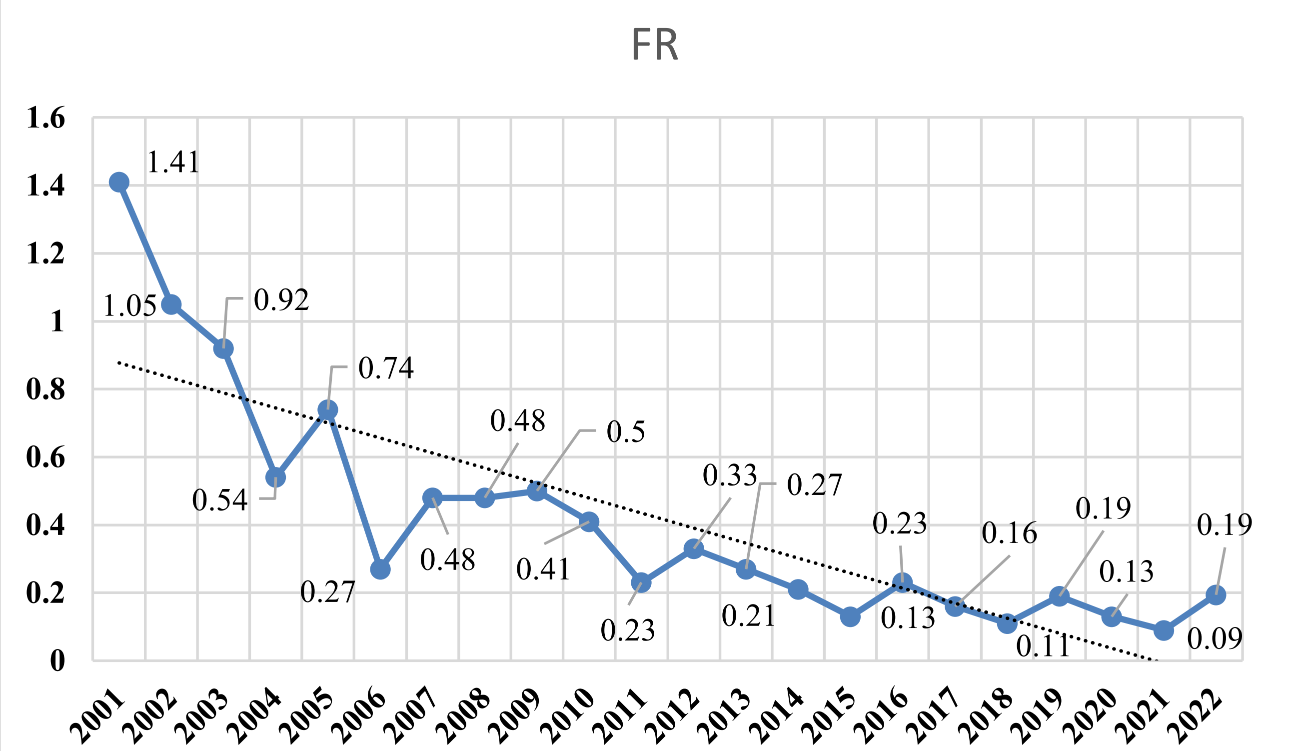


Figure 1.5: Year Wise Comparison of Frequency Rate along with its trend

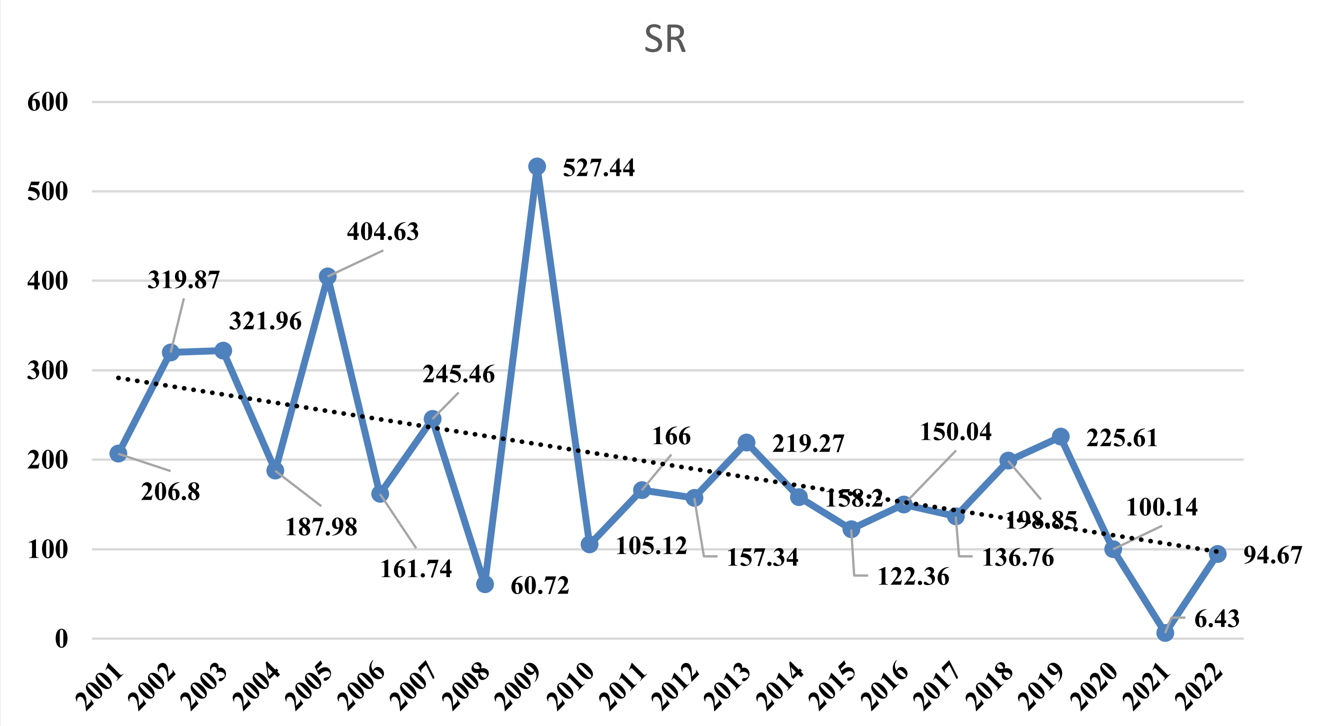


Figure 1.6: Year Wise Comparison of Severity Rate along with its trend

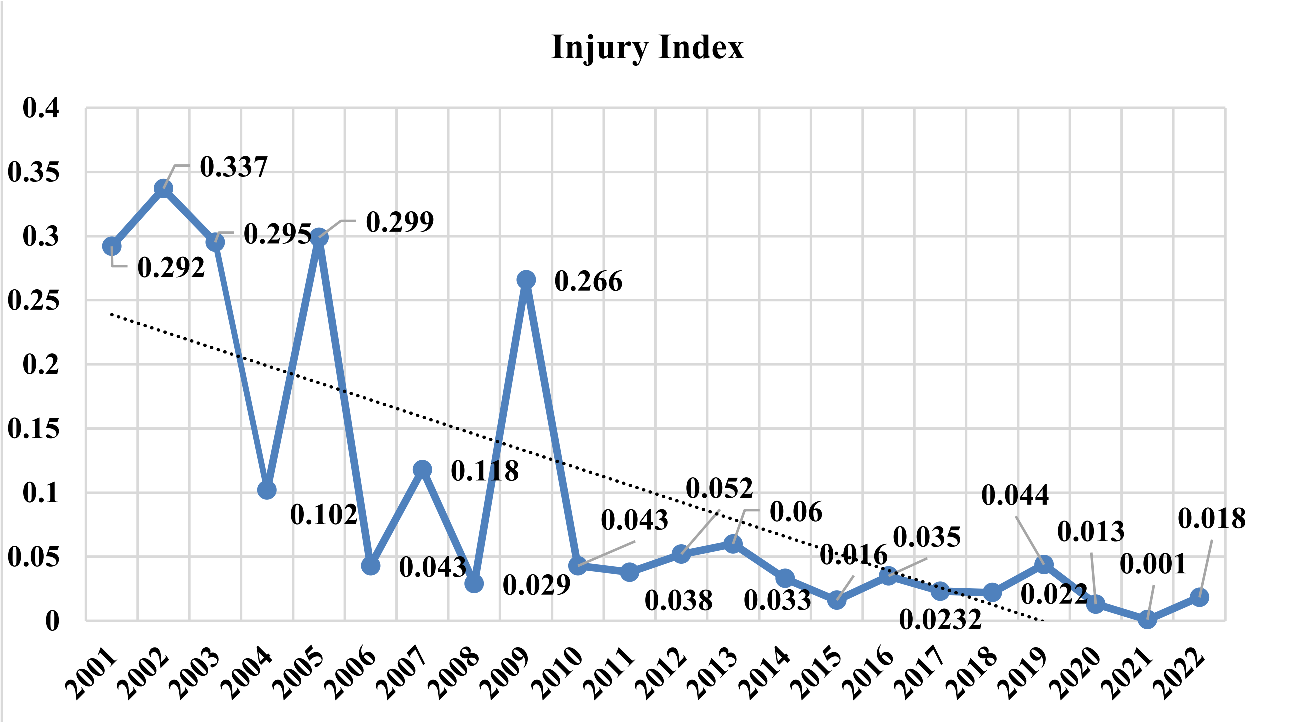


Figure 1.7: Year Wise Comparison of Injury Index along with its trend

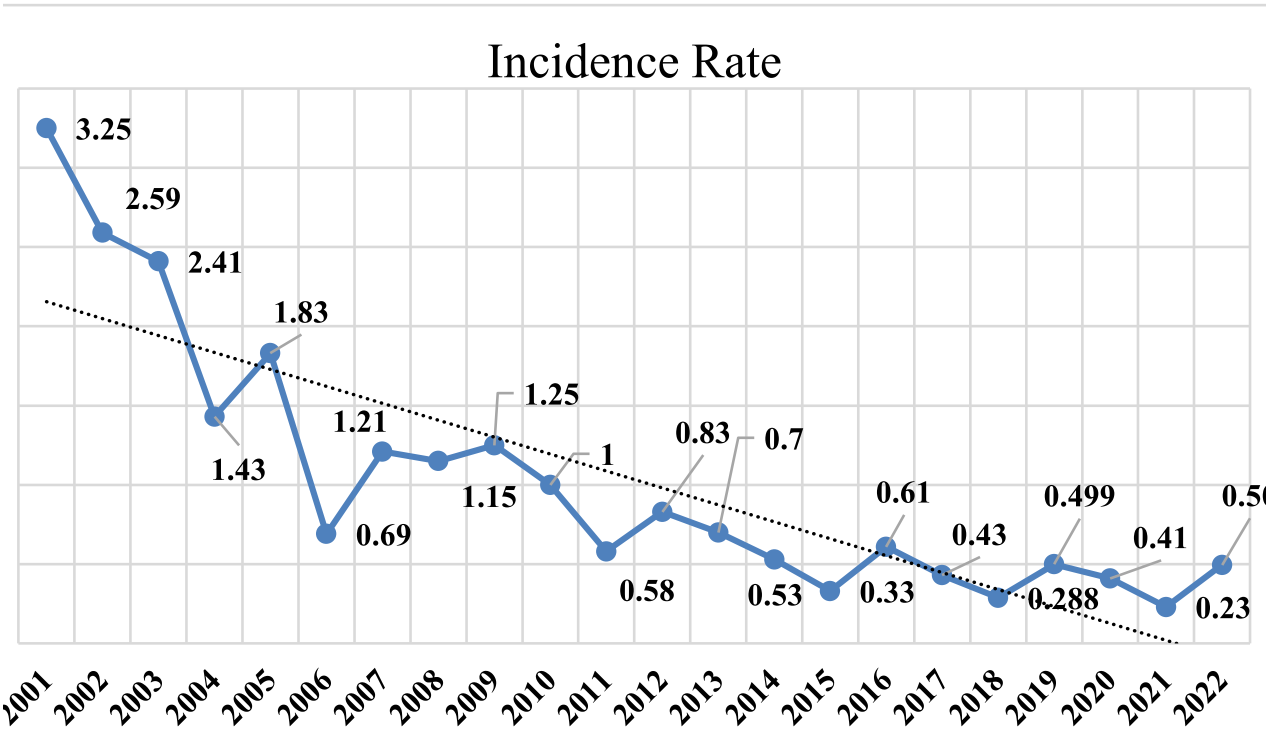


Figure 1.8: Year Wise Comparison of Incidence Rate along with its trend

1.15 Safety Performance Indicators of Operating Nuclear Power Plants (NPPs)

AERB monitors safety performance of operating NPPs on annual basis under five safety performance areas namely Nuclear Safety, Radiation Safety, Public & Environment Safety, Emergency Preparedness & Response and Regulatory Compliance. The performance is categorized as very good, good, satisfactory and scope of improvement based on assesment. The results of safety performance for the year 2023 are as follows:

<table>
<tr><th rowspan="3">Sr. no.</th><th rowspan="3">Safety Performance Area</th><th colspan="18">PHWRs</th><th colspan="2">BWRs</th><th colspan="2">LWRs</th></tr>
<tr><th colspan="2">RAPS-1&2</th><th colspan="2">MAPS-1&2</th><th colspan="2">KAPS-1&2</th><th colspan="2">NAPS-1&2</th><th colspan="2">KGS-1&2</th><th colspan="2">RAPS-3&4</th><th colspan="2">KGS-3&4</th><th colspan="2">RAPS-5&6</th><th colspan="2">TAPS-3&4</th><th colspan="2">TAPS-1&2</th><th colspan="2">KKNPP-1&2</th></tr>
<tr><th>U-1</th><th>U-2</th><th>U-1</th><th>U-2</th><th>U-1</th><th>U-2</th><th>U-1</th><th>U-2</th><th>U-1</th><th>U-2</th><th>U-3</th><th>U-4</th><th>U-3</th><th>U-4</th><th>U-5</th><th>U-6</th><th>U-3</th><th>U-4</th><th>U-1</th><th>U-2</th><th>U-1</th><th>U-2</th></tr>
<tr><td>1</td><td>Nuclear Safety</td><td>Very Good</td><td>Very Good</td><td>Very Good</td><td>Very Good</td><td>Very Good</td><td>Very Good</td><td>Very Good</td><td>Very Good</td><td>Very Good</td><td>Very Good</td><td>Very Good</td><td>Very Good</td><td>Satisfactory</td><td>Very Good</td><td>Very Good</td><td>Very Good</td><td>Very Good</td><td>Very Good</td><td>Very Good</td><td>Very Good</td><td>Very Good</td><td>Very Good</td></tr>
<tr><td>2</td><td>Radiation Safety</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td></tr>
<tr><td>3</td><td>Public & Environment Safety</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td></tr>
<tr><td>4</td><td>Emergency Preparedness & Response</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td></tr>
<tr><td>5</td><td>Regulatory Compliance</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Good</td><td colspan="2">Satisfactory</td><td colspan="2">Very Good</td><td colspan="2">Very Good</td><td colspan="2">Good</td><td colspan="2">Good</td></tr>
</table>

SPI Rating		Colour Code
Scope for Improvement	सुधार की गुंजाइश	Red
Satisfactory	संतोषजनक	Yellow
Good	अच्छा	Blue
Very Good	बहुत अच्छा	Green

Safety Performance Assessment of Operating NPPs for the Year 2023

CHAPTER -02

SAFETY SURVEILLANCE OF RADIATION FACILITIES

SAFETY SURVEILLANCE OF RADIATION FACILITIES

Radiation sources such as radioisotopes (^{60}Co, ^{137}Cs, ^{192}Ir, ^{75}Se, ^{241}Am, ^{99m}Tc, ^{85}Kr etc.) and radiation generating equipment (X-ray machines, accelerators etc.) are being used in multifarious applications in industry, medicine, agriculture and research for societal benefits. AERB regulates facilities using radiation sources in order to ensure radiation safety. These sources have radiation hazard potential ranging from very low to high. Proper design, handling and disposal methodologies are required for ensuring safe use of radiation sources, for the intended purpose.

2.0 Safety Review Mechanism of Radiation Facilities

As per the Atomic Energy (Radiation Protection) Rules, 2004, promulgated under the Atomic Energy Act, 1962, AERB reviews radiation safety in radiation facilities and issues regulatory consents in the form of Licence, Authorisation, Registration and Consent/Approvals based on the hazard potential. The regulatory requirements and safety review levels are applied following graded approach, before issuance of consent to operate the facility/equipment. The graded approach followed is depicted in Figure 2.1.

Type Approvals are issued to equipment conforming to the regulatory standards. No Objection Certificates (NOC) are issued to the suppliers to import either radiation generating equipment or equipment containing radioactive source, based on which the end-users apply for procurement permission. The performance tests / radiological assessments are witnessed by AERB for issuance of Type Approval. Only Type Approved equipment are licensed for operation by AERB.

AERB follows multi-tier review process for issuance of various consents to radiation facilities, based on the hazard potential involved. The safety review for radiation facilities' applications is carried out as per AERB Safety Guide on 'Consenting Process for Radiation Facilities' (AERB/RF/SG/G-3). AERB also issues shipment approval from radiological safety standpoint to facilitate safe transport of radioactive materials. The details of radiation facilities for various practices regulated by AERB are given in Table 2.1.

Table 2.1: Details of Radiation Facilities and Equipment/Sources as on 31st December 2023

Practice	Total no. of Institutions	Modalities	Total no of Equipment/Sources
Radiotherapy	649	Proton Therapy Facility	2
		Telecobalt	174
		Gamma Knife	6
		Accelerator	736
		Tomotherapy	33
		Cyber knife	11

Practice	Total no. of Institutions	Modalities	Total no of Equipment/Sources
Radiotherapy		HDR Brachytherapy Unit	401
		Intra Operative Radiation Therapy (IORT)	03
		Simulator and CT-Simulator	202
Nuclear Medicine	528	PET-CT	465
		PET-MR	5
		SPECT-CT	106
		SPECT/Gamma Camera	251
		Therapy Installations	166
		Radioimmunoassay (RIA)	64
Research/Academic Institutions using Sealed/Unsealed Sources	190	-	-
Diagnostic Radiology	73282	Radiography (Fixed)	39,494
		Radiography (Mobile)	38,025
		Radiography (Portable)	1,601
		Radiography and Fluoroscopy	2,427
		Interventional Radiology	3,895
		Computed Tomography	11,569
		Dental (Intra-oral, OPG, CBCT)	26,614
		Mammography	3,399
		C-Arm	28,941
		O-Arm	47
		Bone Densitometer	1,074
Industrial Radiography	768	Industrial Gamma Radiography Exposure Device	2,602
		Industrial X-ray Radiography Device	895
		Accelerators	20
Nucleonic Gauge	1278	Nucleonic Gauges Devices	9,178
Well Logging	55	Well Logging Sources	1,878
Radiation Processing Facilities	47	GRAPF	31
		IARPF	16

Practice	Total no. of Institutions	Modalities	Total no of Equipment/Sources
Gamma/X-Ray Irradiation Chamber	110	Gamma Irradiation Chamber (GIC)	123
		X-Ray Irradiation Chambers	10
Medical Cyclotron Facilities	22	Medical Cyclotron	22
Research Accelerator Facilities	11	Research Accelerator	11
Container Scanning Facilities	22	Radioisotope based Container Scanners	3
		Accelerator based Container Scanners	26

The Graded Approach in Consenting Process based on Radiation Hazard Potential

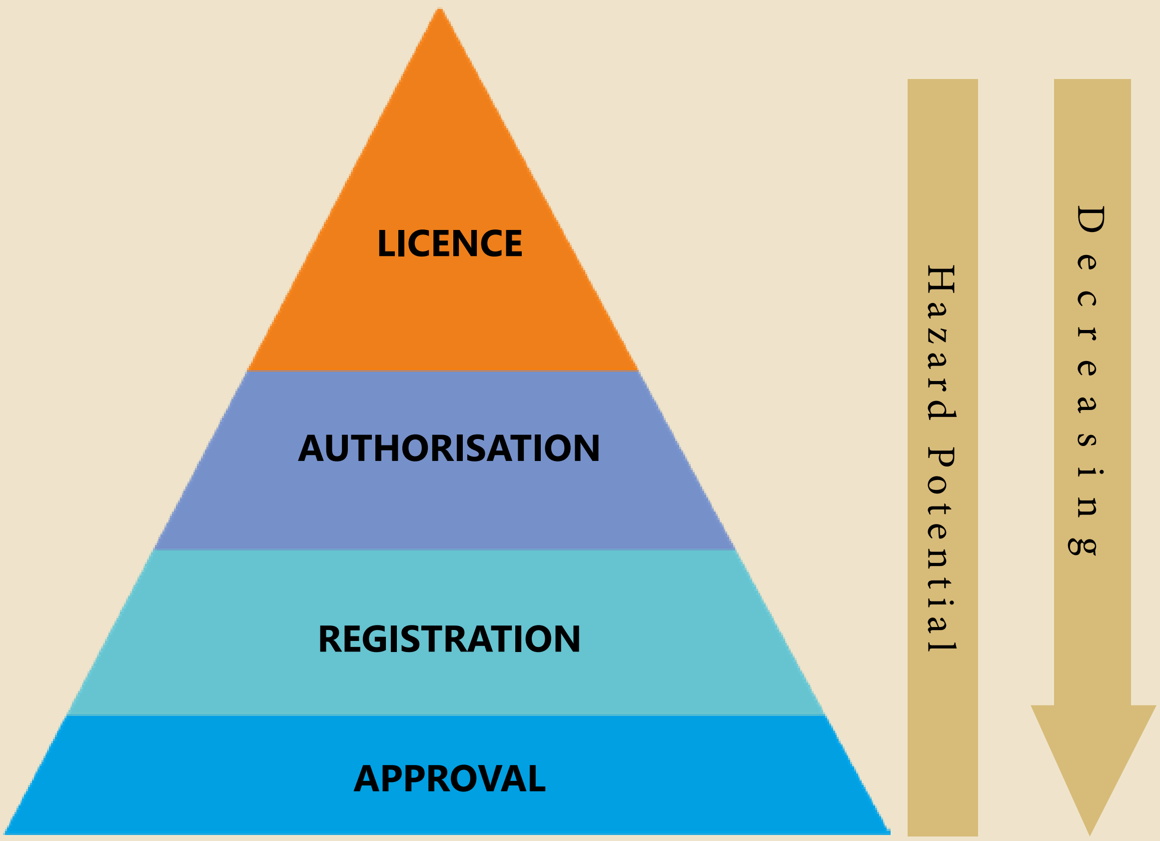


Figure 2.1 Graded Approach in Consenting Process

2.1 Applications of Radiation Sources and Regulatory Activities

An overview of various applications of radiation sources and details of license/consents issued during the year 2023 to radiation facilities are elaborated in the following paragraphs

2.2 Medical Applications of Radiation Sources

2.2.1 Radiation Therapy

(i) Teletherapy

Teletherapy is a branch of radiation therapy, which deals primarily with treatment of cancer,

using ionising radiation, where in the radiation source(s) are kept at a certain distance from the patient. ^{60}Co radioisotope emitting gamma rays or radiation generators such as Linear Accelerators (LINAC) emitting X-ray or electron beams are mainly used for the treatment. Sources and devices used in teletherapy are of high radiation hazard potential.

An indigenously developed Medical Accelerator Model "SIDDHARTH-II ICONIC PLUS", was tested for its safety performance and based on its satisfactory performance, Type Approval was issued by AERB for the equipment to the Indian manufacturer.

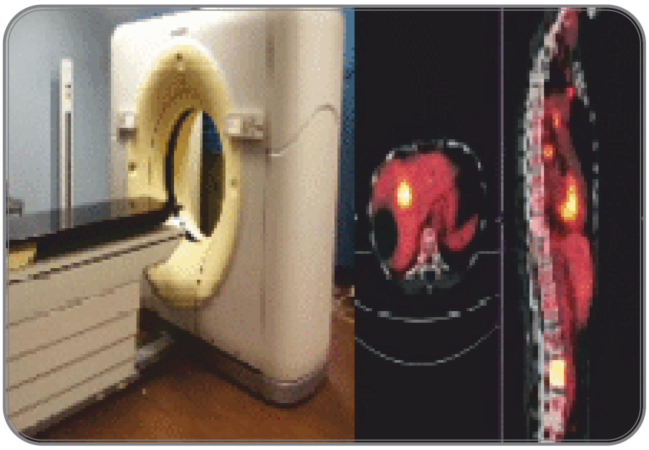
(ii) Proton Beam Therapy

It is a type of teletherapy using proton beams having energies in the range of 70 MeV to 230 MeV. Proton beams are specifically beneficial in treating paediatric cancers and deep-seated tumours more effectively than the conventional Gamma/X-ray based radiation therapy. Proton Therapy is a cutting-edge treatment modality which offers unique benefits in treating cancer with high precision and minimal impact on healthy tissues.

AERB issued licence for operation from radiological safety view point to Advanced Centre for Treatment, Research and Education in Cancer (ACTREC), Mumbai; for the operation of Gantry Treatment Room-3 (GTR-3) of Proton Therapy facility model Proteus Plus, after satisfactory safety review and prelicensing inspection. This is the first Proton Therapy Facility in India established in a Government set-up.

(iii) Brachytherapy

In brachytherapy, radiation source is kept very near to or inside the lesion. The radioisotopes used are typically ^{192}Ir, ^{137}Cs, ^{90}Sr, ^{106}Ru, ^{125}I and ^{60}Co with activity range from few MBq to GBq. They are of moderate radiation hazard potential as compared to teletherapy.



2.2.2 Nuclear Medicine

Nuclear medicine imaging has special importance as it can detect the molecular level activity within the body which helps in identification of disease in its early stage and the metastasis growth in cancer. For diagnosis purpose, the gamma rays emitted from the radio isotopes such as ^{99m}Tc, ^{18}F, ^{201}Tl, ^{67}Ga, ^{68}Ga are detected by special detection devices (e.g. Gamma Camera, SPECT, PET) and images are reconstructed using computer algorithms. For therapeutic purpose, beta emitting radioisotopes such as ^{131}I, ^{177}Lu, ^{153}Sm, ^{90}Y, ^{32}P, ^{188}Re are used which deliver localised radiation dose once radio-pharmaceutical accumulates at the area of interest. The facilities using radio-pharmaceuticals are of moderate to low radiation hazard potential.

Type Registration was issued for new SPECT nuclear medicine imaging equipment installed at AIIMS, Delhi, based on satisfactory demonstration of quality assurance tests.

2.2.3 Diagnostic Radiology (X-ray)

X-rays are used in medical facilities as an important diagnostic tool. A wide variety of X-ray equipment are used for various diagnostic examinations.

The details of Medical Radiation Facilities/ Equipment and Consents issued for various medical facilities during the year 2023 are given in Table 2.2.

Interventional Radiology equipment (Cath-Lab)

These equipment are used in operation theatres for various interventional procedures and pose moderate radiation hazard to patients and medical professionals involved in operation of the equipment

Computed Tomography (CT)

CT is a non-invasive medical examination that uses X-ray equipment to produce cross-sectional images of the body. CT equipment pose moderate radiation hazard potential to both worker and patients.

Radiography and Fluroscopy

Radiography, Fluoroscopy, Dental X-ray, Mammography, Bone Mineral Densitometer equipment are used for diagnostic purpose. These constitute around 70-80% of all X-ray equipment that are used, and are of low-to-very low radiation hazard potential, to both worker and patients.

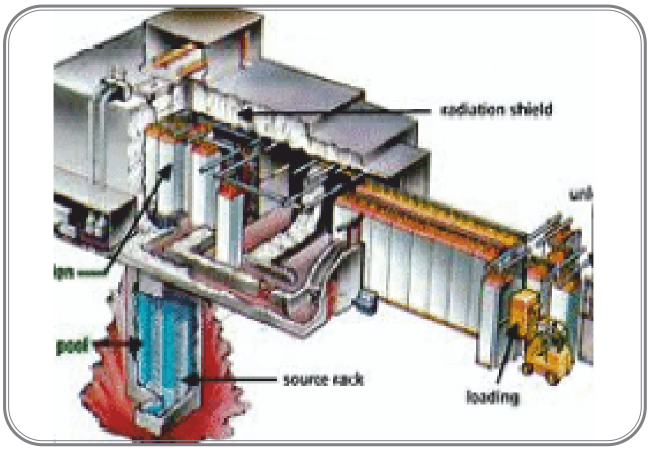
Table 2.2: Details of Consents/Renewals issued for Medical Radiation Facilities in the Year 2023

Type of Consent	Radiation Therapy	Nuclear Medicine	X-ray
Licence*	317	356	23,136
Permission for Import/Procurement of Equipment from Radiation Safety Stand Point	748	99	13,575
Permission for Procurement of Radioactive Sources	-	2,870	-
Type Approval/Renewal /Type Registration (Equipment) from Radiation Safety Stand Point	30	1	379
Layout Approval	401	206	-

*Licence includes Licence / Authorisation / Registration for various radiation facilities

2.3 Industrial Applications of Radiation Sources

2.3.1 Radiation Processing Facilities (RPF)

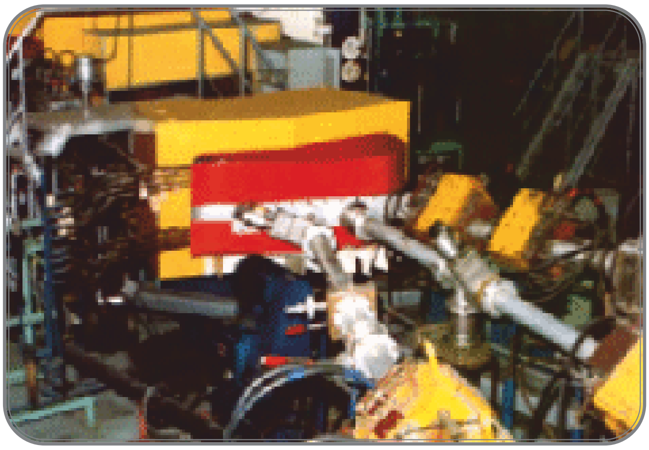


Radiation Processing Facilities (RPF) include Gamma Radiation Processing Facility (GRAPF)/ Gamma Irradiators and Industrial Accelerators Radiation Processing Facility (IARPF). GRAPFs are mainly used for radiation processing of food (viz. inhibiting sprouting, delay in ripening, microbial decontamination, insect disinfestation, shelf-life extension etc.) and sterilisation of healthcare products. ^{60}Co is used as a radiation source with activity of about few PBq. IARPF are mainly used for cross-linking of polymers in cable industries and are operated in electron beam mode with energy ranging from 1.5 MeV to 3 MeV. Such accelerators, unlike radioactive sources, produce radiation only when energized. The RPFs are of high radiation hazard potential.

AERB issued Approval for technology demonstration of first of its kind 'Low Temperature Gamma Irradiator' installed at BRIT, Vashi (having 100 kCi ^{60}Co source). This is a Category-I, self-contained, dry storage irradiator to irradiate food, marine and medical products.

2.3.2 Research Accelerators

Research Accelerators or Particle Accelerator Research Facilities (PARF) are generally installed in academic & research institutions and cater to the research needs of various fields of high energy physics, material science, radiation studies



etc. Research Accelerators operate in the energy range from a few hundreds of keV to GeV. The hazard associated with the facilities is also diverse in nature and ranges from moderate to high. The radiation hazard potential of an accelerator mainly depends on the type of ion(s) accelerated, type of accelerator and beam parameters (e.g. energy & current, target system).

2.3.3 Medical Cyclotron

Short-lived radioisotopes that are used in nuclear medicine for PET scans are generally produced in medical cyclotron facilities. In India, cyclotrons are primarily utilised for the production of ^{18}F labelled radio-pharmaceuticals. The hazard

potential associated with medical cyclotron facilities ranges from moderate to high.

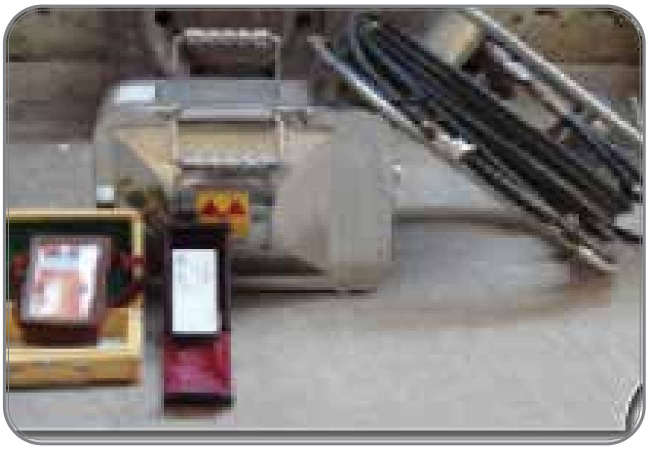
2.3.4 Gamma /X-ray Irradiation Chamber (GIC/XIC)

Gamma Irradiation Chambers are basically used for research and development purposes and also in blood banks for irradiation of blood and blood components. Radioisotopes like ^{60}Co and ^{137}Cs are normally used in these applications. The activity ranges from few tens of TBq to few hundreds of TBq. X-ray based Irradiation Chambers with

X-ray energy ranging from 160 keV to 300 keV are also being used in blood banks and research applications. These equipment are of moderate to high hazard potential.

2.3.5 Industrial Radiography (IR)

Radiography using Industrial Radiography Exposure Device (IRED), is one of the important Non-Destructive Testing (NDT) methods used for study / evaluation of weld joints, castings etc. Radioisotopes like ^{192}Ir, ^{60}Co, ^{75}Se and different energies of X-rays are used in the field of industrial radiography. The activity of radioisotopes range from few hundreds of GBq to few TBq whereas in case of X-ray based devices, the low energy X-ray ranges from 50 kV-450 kV and high energy X-ray ranges from 4MV-15MV. IREDs are of moderate-to-high radiation hazard potential.

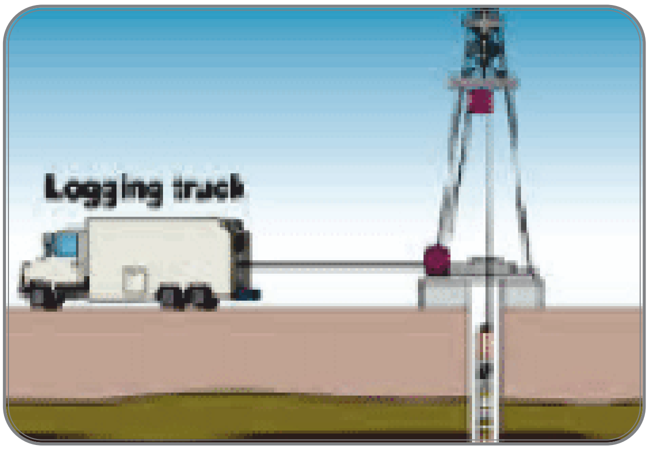


2.3.6 Nucleonic Gauges (NG)

Nucleonic Gauges also known as Ionizing Radiation Gauging Devices (IRGD) are used for online measurement/monitoring of quality control parameters such as thickness, level,

density, coating thickness, composition of material, elemental analysis etc. Sources used in nucleonic gauges depends on the application for which the gauges are intended and comprise of gamma sources (e.g. ^{60}Co, ^{137}Cs, ^{241}Am etc.), beta sources (e.g. ^{85}Kr, ^{90}Sr, ^{147}Pm, ^{204}Tl) and neutron sources (^{241}Am-Be and ^{252}Cf). The activity ranges from MBq to GBq. In addition, X-ray based gauges of energy in the range of 30 keV to 160 keV are also used in industries for coating thickness measurement. IRGDs are of low-to-moderate radiation hazard potential.

2.3.7 Well Logging (WL)



Radioactive sources are used in Well Logging applications for exploration of oil, coal and geophysical logging etc. The sources used are mainly gamma sources such as ^{137}Cs for density measurement and neutron sources such as ^{241}Am-Be and Deuterium-Tritium generators (neutron generators) for exploration of hydrocarbons. The activity ranges from kBq to GBq. They are of low-to-moderate radiation hazard potential.

2.3.8 License for Operation of Radiopharmaceutical Facility

Based on safety review, License for operation was issued to Radiopharmaceutical facility,Vijaywada for manufacturing and supplying ^{131}I labelled

radiopharmaceuticals to AERB authorised nuclear medicine centres.

2.3.9 Type B(U) Design Approval for Industrial Radiography Device Model ROTEX-1

Based on satisfactory safety review, AERB issued Type B(U) design approval to an indigenously developed remote operated Industrial Radiography Device (Model ROTEX-1) of BRIT.

The device contains ^{192}Ir source of 2.4 TBq (65 Ci) capacity with tungsten shield.

2.4 Consumer Products, Scanning and Research Applications

2.4.1 Consumer Goods Manufacturing Facilities

Consumer products such as smoke detectors,

thorium gas mantles and starters, gaseous tritium luminescence devices use miniscule amounts (i.e exempt quantity) of radioactive sources. They are of very low hazard potential. However, AERB exercises regulatory control on the manufacturing facilities of these devices. Those products containing radioactivity above the exempt limits have to be assessed for safety and are required to be type approved by AERB.

2.4.2 Container Scanner Facility

Container scanners are used at various ports (land/sea) for inspection of material inside cargo/ container without opening them. These systems are based on either Linear Accelerators (photon energy in the range of 6 to 9 MV) or ^{60}Co isotope (activity of the order of 1 Ci). They contain moderate-to-high radiation hazard potential.

Licenses for operation of accelerator based Drive Container Scanner were issued to M/s Gangavaram Port Ltd., Vizag and M/s Syama Prasad Mookerjee Port, Kolkata.

2.4.3 X-ray Baggage Scanner

Scanning facilities are used for detection of contrabands and explosives. Scanning facilities are mainly X-ray based equipment of energy around 160 kV and of extremely low radiation hazard potential. Design (Type) Approval of the equipment is carried out by AERB from radiation stand point of view.

2.4.4 Facilities using Sealed and Unsealed Sources

Various sealed and unsealed sources are used in education, research and calibration purposes in academic and research institutions. Unsealed sources are also used in agriculture research, veterinary science, tracer studies, etc. The activity ranges from kBq to GBq. They are of low-to-moderate radiation hazard potential.

The details of Industrial Radiation Facilities/ equipment and consents/renewals issued for various industrial facilities during the year 2023 are given in Table 2.3.

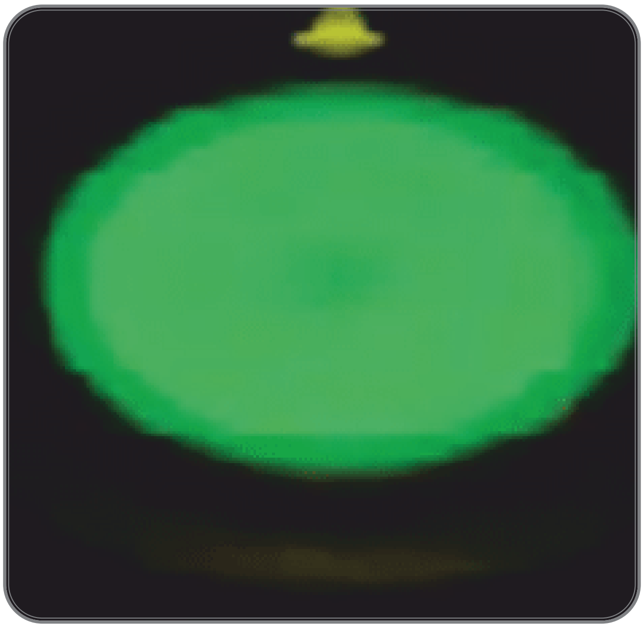


Table 2.3: Details of Consents issued for Industrial Radiation Facilities during the year 2023

Type of Consent	RPF	Research Accelerators	Medical Cyclotron	GIC	IR	NG	WL
Licence*	22	00	2	36	218	305	8
Type Approval / Renewal Equipment	-	-	-	12	30	43	-
Type Approval / Renewal Sources	-	-	-	0	-	25	3
Permission for Import/ Procurement of Equipment From Radiation Stand Point	10 (IAPRF)	-	-	-	334	602	-
Permission for Procurement of Radioactive Sources	20	-	-	15	1,688	126	216
Approval (Layout/ Commissioning/ Source Storage Facility/D&C)	10	-	1	22	388	-	8

*Licence includes Licence / Authorisation / Registration for various radiation facilities

The details of Consumer Products and Scanning Facilities / equipment and consents issued for various consumer products and scanning facilities during the year 2023 are given in Table 2.4.

Table 2.4: Details of Consents/Renewals issued for Consumer Products and Scanning Facilities for the Year 2023

Type of Consent	Consumer Goods Manufacturing Facilities	Container/ Baggage Scanner	Research Facilities (Sealed and Unsealed Sources)
Licence*	-	1,151	72
Permission for Procurement of Radioactive Sources/ Equipment From Radiation Stand Point	-	1,601	274
Type Approval (Source & Equipment) From Radiation Stand Point	-	330	-

*Licence includes Licence / Authorisation / Registration for various radiation facilities

2.5 Approval of Radiological Safety Officers

While the built-in safety of the equipment and institution's operational preparedness towards operational safety are ensured by adhering to requirements specified by AERB in various regulatory safety documents, Radiological Safety Officer (RSO) carries out the implementation of radiation safety. The RSOs act as extended arms of AERB at every radiation facility and also play pivotal role between the facility and the regulatory body. The number of RSO approvals/ renewals issued for different practices during the year are as given in Table 2.5.

Table 2.5: Approval of Radiological Safety Officers in Radiation Facilities for the Year 2023

Type of Practice	Number	Type of Practice	Number
Radiation Therapy	432	Medical Cyclotron	15
Nuclear Medicine	400	Industrial Radiography	506
Diagnostic X-ray Facilities	3444	Nucleonic Gauges	460
Research Centres	104	Well Logging	32
Radiation Processing Facilities	59	Consumer Product Manufacturer & Scanner Facilities	79
Gamma Irradiation Chamber	58		

2.6 R&D Units and other Facilities in Construction and Operation

AERB also exercises regulatory oversight on certain R&D and other facilities of the Department of Atomic Energy (DAE). These include Variable Energy Cyclotron Centre (VECC), Raja Ramanna Centre for Advanced Technology (RRCAT), Indira Gandhi Centre for Research (IGCAR) and Board of Radiation & Isotope Technology (BRIT). The status of R&D units and other facilities is presented in Table 2.6 below.

Table 2.6: Status of R&D Units and Other DAE Facilities

Type of Facility	Name	Functional Status	Scope of the Facility	Validity of Current Licence
Facilities operated by VECC, Kolkata, West Bengal				
Particle Accelerator Research Facility (PARF)	Room Temperature Cyclotron (K-130)	In operation	Heavy Ion Acceleration	September 1, 2027
	Super Conducting Cyclotron (K-500)	Commissioning	Heavy Ion Acceleration	-
	Medical Cyclotron Project	Stage-2 Commissioning	Cyclotron Machine along with 3 Beam Lines for Production of Radio-Pharmaceuticals and 2 Beamlines for Research Purpose	January 13, 2024
Facilities operated by RRCAT, Indore, Madhya Pradesh				
LASER	150 TW Ti: Sapphire Laser System	In operation	90 TW (for regular) and 150 TW (trial) (25 femto-second)	June 30, 2026
IARPF	Agricultural Radiation Processing Facility (ARPF)	In operation	Electron Acceleration, 2 x (10 MeV, 5 kW) Technology Demonstration for Food Irradiation	January 11, 2029
	INDUS-1	In operation	450 MeV, 100 mA Electron Storage Ring	March 31, 2026
	INDUS-2	In operation	2.5 GeV, 200 mA Synchrotron Radiation Source (SRS)	March 31, 2026

Type of Facility	Name	Functional Status	Scope of the Facility	Validity of Current Licence
LASER	1 PW Laser System	Commissioning and Trail Run	1 PW (femto second)	March 15, 2024
Superconducting RF Cavity (SCRF)	Horizontal Test Stand for SCRF	Operation and Testing of SCRF Cavities	Testing of SCRF Cavities at 650 MHz	September 12, 2027
Superconducting RF Cavity (SCRF)	Vertical Test Stand of SCRF	Operation and Testing of SCRF	Testing of Single Cell or Multi Cell SCRF Cavities	January 19, 2028
Facilities operated by IGCAR, Kalpakkam, Tamil Nadu				
Accelerator	1.7 MV Tandetron Accelerator	In operation	Heavy Ion Acceleration	August 31, 2026
	150 kV Accelerator	In operation	Heavy Ion Acceleration	August 31, 2026
Facilities operated by BRIT				
Board of Radiation and Isotope Technology	BRIT, Navi Mumbai	In operation	Production of Radio-Isotopes used in Radiation Facilities, Radio- Pharmaceutical mainly for Nuclear Medicine Application, Radiation Processing etc.	January 31, 2029
	BRIT-RAPPCOF, Kota	In operation	Production of Radio-isotopes mainly for Radiation Processing Plants	January 31, 2029

2.6.1 RRCAT Facilities

Raja Rammana Centre for Advanced Technology (RRCAT) is engaged in R&D in front line research areas of Lasers, Particle Accelerators and related technologies.

Following Licenses were issued for various facilities of RRCAT:

- Licence (renewal) for Operation of Vertical Test Stand (VTS) of RRCAT, Indore and testing of Superconducting RF cavities (SCRF) was issued on January 20, 2023.
- Amendment of Licence for Operation of Agricultural Radiation Processing Facility (ARPF) of RRCAT was issued on July 10, 2023.
- AERB extended Licence for Operation of Indus-1 Accelerator facility in September, 2023.

- Consent for Commissioning and Trial Run operation of Linac Test Stand Facility in IMA Building of RRCAT, Indore was issued on September 21, 2023.
- Consent for Commissioning and Trial Run Operation of 1 PW Laser System at RRCAT, Indore was issued on September 21, 2023.
- Permission for Trial Run of TWINDUS-LINAC-4 at IMA Building, RRCAT, Indore was issued on October 27, 2023.

2.7 Unusual Occurrences/ Enforcement Actions

2.7.1 Enforcement action was taken against an Industrial Radiography institution located in Delhi for making false claim regarding availability of Radiological Safety Officer. The licence was suspended for a period of six months.

2.7.2 Licence for operation issued to an Industrial Radiography institute located in Mathura,UP was suspended for a period of six months for operating industrial radiography equipment without licence and without Personnel Monitoring Services (PMS) for the radiation workers. The approval issued to the RSO was also withdrawn.

2.7.3 Licence for Operation of an Industrial Radiography facility located in Trichy, was suspended for six months for engaging untrained personnel, use of enclosure without valid consent and high radiation levels outside the radiography enclosure. The approval issued to the RSO was also withdrawn on failure of discharging the responsibilities.

2.7.4 Licence for operation of an Industrial Radiography facility located in Ahmednagar was suspended for a period of six months for falsely declaring RSOs in e-LORA system.

2.7.5 Registrations of two RSOs of Industrial Radiography institutes were withdrawn from e-LORA system on failure of discharging their responsibilities.

2.8 Management of Disused Radioactive Sources

The radiation sources are either procured from Indian supplier or imported from other countries. All the radioactive sources must be safely managed when they reach the end of their useful life or if they are not in use for intended purpose. As per the terms and conditions of the Licence, these disused sources need to be sent back to the original manufacturer/supplier for its safe management.

557 approvals were issued for export (towards repatriation) of radioactive sources to the country of origin, and 333 approvals were issued for returning the sources to the Indian supplier, for their safe management during the year 2023.

Moreover, there were 23 ^{60}Co Category-1 disused sources in telecobalt units, of which 9 were decommissioned, 5 were restarted and the remaining 9 are under regular follow-up for decommissioning. In 2023, 2 units have been decommissioned and one has restarted.

Similarly, there are 24 ^{60}Co Category-1 disused sources used in GICs and GRAPFs, of which 14 are decommissioned in 2023, and 10 are under decommissioning.

AERB is in communication with the concerned institutions regarding safety status and follow-up actions for decommissioning of the disused sources. Frequent inspections are conducted for facilities possessing disused Category-1 sources.

2.9 Safety Committees for Radiation Facilities

AERB has constituted several safety committees for safety review based on hazard potential of RFs. The safety committees review the radiation safety aspects of RFs using radioactive sources / radiation generating equipment. The committees also recommend issuance of Licence for Operation or issuance of Type Approval, based on safety review and assessment. The committees consist of experts from the industry, medical and academic institutions apart from the experts from BARC, BRIT and AERB. Number of meetings conducted by various committees for safety review of RFs and transport of radioactive material during the year is given in Table 2.7.

Table 2.7: Meetings of Safety Review Committees of Radiation Facilities for the Year 2023

Name of Committee	Number of Meetings
Safety Review Committee for Applications of Radiation (SARCAR)	03
Safety Review Committee for Radiation Processing Plants (SRC-RPP)	02
Committee on Safe Transport of Radioactive Material (COSTRAM)	03
Safety Committee for Hadron Therapy Facilities (SCHTF)	01
Accelerator and Laser Safety Committee (ALSC)	03
Committee for Review of Exposure Cases in Nuclear Fuel Cycle and Radiation Facilities (CRENRAF)	04

CHAPTER -03

REGULATORY INSPECTIONS

REGULATORY INSPECTIONS

Regulatory Inspections (RI) is one of the key processes of AERB through which it ensures that the activities performed by the Licensee during all the phases (viz. siting, construction, commissioning, operation, decommissioning, and release from regulatory control) of the life cycle of Nuclear and Radiation Facilities are executed in compliance with the conditions of the License and relevant safety requirements.

3.0 Regulatory Inspection Programme

A comprehensive RI programme is developed and implemented every year, to check that licenced activities/facilities are conducted/operated in accordance with regulatory requirements and in conformity with safety and security objectives. The programme is prepared following graded approach. The frequency, scope and rigour of inspections takes into account the hazard potential of the facility and the consenting stage of the facility. Inputs from previous inspection findings and safety reviews are also considered during the programme development. Adequate provisions for special inspections and reactive inspections (e.g., safety significant events) are incorporated in the programme to take care of unforeseen situations.

Inspections are carried out periodically as well as in special circumstances. Generally, the inspections are carried out with prior announcement. AERB also carries out unannounced inspections with specific objectives. AERB prepares an annual plan based on graded approach, for inspection of nuclear and radiation facilities considering the following:

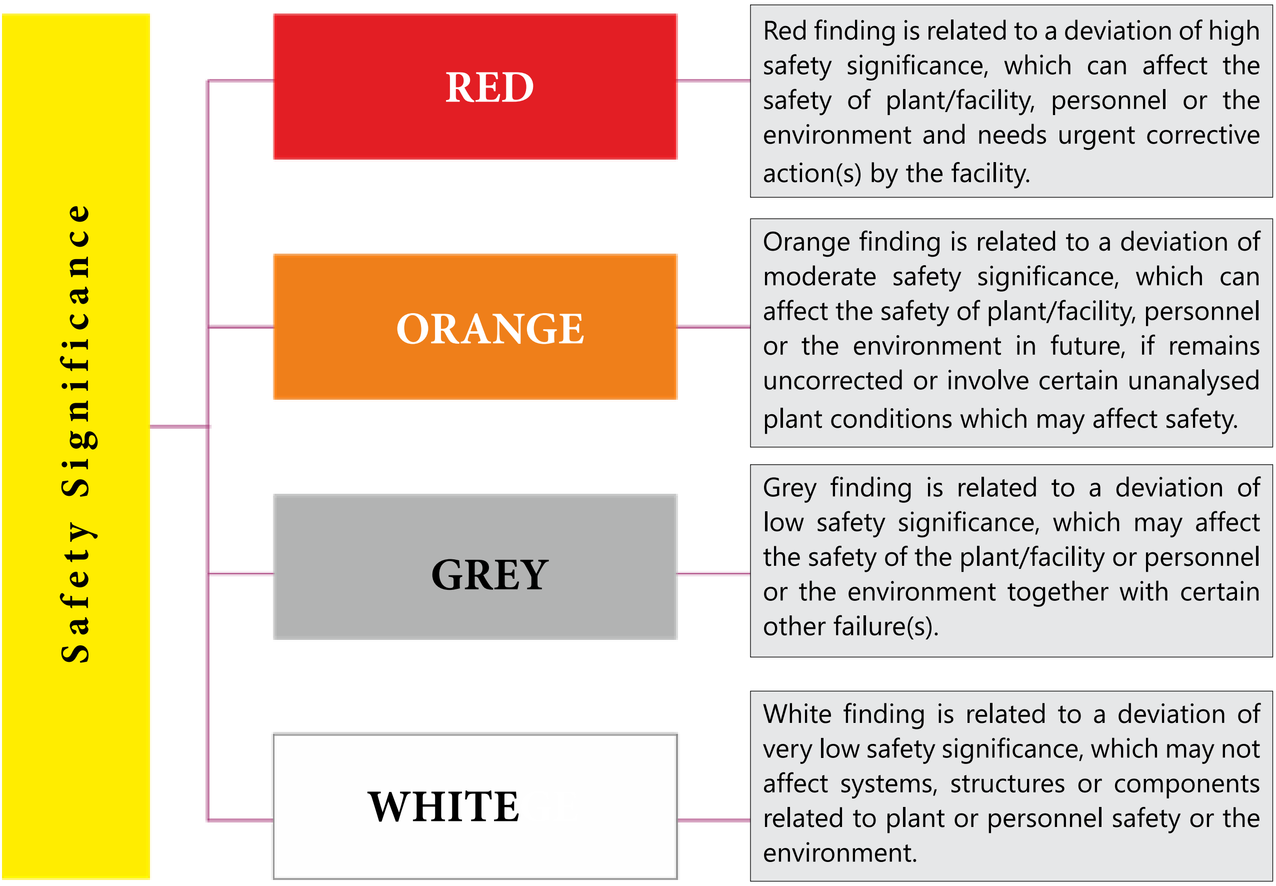
i. Probable degree and nature of the hazard associated with the facility or activity
ii. Outcome of safety review
iii. Progress of activities at the facility
iv. Experience of previous inspections
v. Available resources, and
vi. Guidelines provided in regulatory and IMS documents.

The frequency, scope and rigour of regulatory inspections depend on the hazard potential of the facility and the consenting stage of the facility.

The inspection findings made during the regulatory inspections are broadly categorised adopting a 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 a specified timeframe.

3.1 Graded Approach in Determining Safety Significance of Deviations

Graded approach is followed in determining the safety significance of the deviations observed during the regulatory inspections of nuclear and radiation facilities. The reported deviations are categorised as White, Grey, Orange and Red findings, in the increasing order of safety significance, as described here:



AERB follows-up implementation of the actions for resolution of the reported deviations. Orange and Red findings are reviewed for appropriate follow-up or enforcement actions. The closure of the Grey, Orange and Red findings are considered by AERB after review and acceptance of the corrective actions. Resolution of White findings, by the Licensee is checked by AERB inspectors on sample basis during subsequent inspections to get the information of holistic treatment of Human Organisation & Technical (HOT) factors as an input for safety culture assessment.

Facilities have to submit the action taken report for all types of inspection findings for review and consideration by AERB for closure.

AERB also initiates enforcement action, if in its opinion, the licencee has violated the conditions of the licence wilfully or otherwise or misinformed or did not disclose the information having bearing on safety, after specifying the reasons for such action. The RI team can also initiate on the spot enforcement actions, if necessary, in case of serious non-conformances.

The enforcement actions may include one or more of the following:

i. A written directive for satisfactory rectification of the deficiency or deviation observed during inspection and/ or safety review
ii. Written directive to applicant/licencee for improvement within a reasonable timeframe;
iii. Orders to curtail or stop the activity;
iv. Modification, suspension or revocation of licence/consent; and
v. Initiation of legal proceedings under provisions of the Atomic Energy Act, 1962.

3.2 Regulatory Inspections of Nuclear, Industrial & Radiation Facilities

AERB carries out regulatory inspections of the nuclear, industrial and radiation facilities to ensure compliance with the AERB safety requirements and stipulations. In inspection programme of nuclear and industrial facilities, the emphasis is on aspects related to project management, safety culture, civil construction, quality assurance, equipment storage & preservation, fabrication & erection of major safety related components, documentation, commissioning & operation activities, occupational health & safety, fire safety, nuclear security, radiological monitoring and emergency preparedness.

Additional inspections are conducted to gather information after important events, or to observe specific activities.

AERB has posted onsite observers at four NPP sites (Rawatbhata, Kalpakkam, Kakrapara and Kudankulam) for observing activities at the operating as well as under construction plants at these sites. The important observations are reported to AERB Headquarter (HQ) on daily basis which provides important inputs for safety review and inspections. This has led to establishment of continuous regulatory oversight at these sites, covering twelve operating, four under commissioning, and five under construction NPPs. At other NPP sites, AERB conducts unannounced inspections also, apart from baseline announced inspections.

In case of radiation facilities, the inspection plan envisages prioritization of inspection of the facilities having reported cases of radiation exposures exceeding the prescribed dose limits and the facilities having safety issues identified from safety review/inspections e.g. periodic safety status reports are not received, disused radioactive sources pending for disposal, moderate safety significance (Orange category) inspection findings during previous inspection etc.

AERB Inspection Team at KAPS 1&2

The regulatory inspections are carried out by AERB HQ located at Mumbai and its regional regulatory centres viz.; Eastern Regional Regulatory Centre (ERRC), Kolkata, Northern Regional Regulatory Centre (NRRC), New Delhi and Southern Regional Regulatory Centre (SRRC), Chennai.

The information on RIs conducted at various nuclear, industrial and radiation facilities during the year is given in the following sections:

3.2.1 Regulatory Inspections of Nuclear Facilities and Industrial Facilities

During the year, 129 regulatory inspections of nuclear and industrial facilities were conducted which included Regular inspections, Special inspections (to observe any specific activity or for specific issues identified during licensing, safety review or regulatory inspection processes), and reactive inspections based on the safety significance of the reported events.

During the inspections (Incl. Regular, Special and Reactive inspections), there were 13 deviations reported in Orange Category and no deviation was reported in Red Category. The details of Special and reactive inspections conducted in the year 2023 are given in Table 3.1

Table 3.1:Special and Reactive Inspections Conducted for the Year 2023

Facility	Nature of Inspection	Purpose
Kaiga Site	Special	An inspection of Environmental Survey lab & Onsite Emergency Support Centre(OESC) was conducted on March 27, 2023 to check the present status and preparedness for monsoon season.
KKNPP-3&4	Special	An inspection was conducted on April 25-28, 2023 to inspect welding activities of Main Coolant Pipelines (MCP) at KKNPP-3.
KAPP-3&4	Special	• An inspection was conducted during the period May 22-June 07, 2023 to cover KAPP-4 RB Proof Test & ILRT, PHT Hot Conditioning preparedness and shutdown refuelling/ other activities and to cover plant start-up related activities of KAPP-3. • An inspection was conducted in view of the incident involving injury to a worker due to sudden release of air pressure from coolant channels on August 22, 2023. In this incident, air ingressed from Emergency Core Cooling System (ECCS) water accumulator, which resulted in ejection of temporary caps of coolant channels and sudden release of air pressure. • A special RI on Nuclear Security aspects was carried out to check site's preparedness and compliance to nuclear security requirements.

Facility	Nature of Inspection	Purpose
Rajasthan site	Special	• Inspection was conducted during May 02-04, 2023 to check Station preparedness towards removal and transfer coolant channel components during EMCCR campaign of RAPS-3. • Inspections were conducted during August 23-24, 2023 and Dec 04-05, 2023 to check Station preparedness for activities associated with installation of coolant channels during EMCCR campaign of RAPS-3. • Inspection of OESC-RR site was carried out during October 10-11, 2023 to assess the site conditions.
PFBR	Reactive	An event of sodium leakage from the SGDHR Loop-2 occurred at PFBR site on December 8, 2023. An unannounced reactive RI was conducted to investigate the event.
HWP-Thal	Special	An inspection was conducted on December 23, 2023 to check compliance w.r.t an orange category deviation reported in previous regular inspection.

The number of inspections (Including Regular, special and reactive inspections) conducted in each of Nuclear Facilities (under construction & commissioning), Operating NPP and Industrial & Fuel Cycle Facilities are given in Table 3.2, 3.3 and 3.4 respectively.

Table 3.2: RIs of NFs (Under Construction and Commissioning)

Project(s)	No. of Inspections	Project(s)	No. of Inspections
KKNPP-5&6	2	DFRP*	3
KKNPP-3&4	3	NFC-Kota*	3
KAPP-3&4	6	KAIGA-5&6	2
RAPP-7&8*	4	GHAVP	2
PFBR	4	OESC RR site	1
Total Inspections		**30**	

*Inspection covering Nuclear Security Aspects

Table 3.3 RIs of Operating Nuclear Facilities & NPCIL HQ

Facilities	No. of Inspections	Facilities	No. of Inspections
Operating NPPs			
TAPS-1&2	4	NAPS-1&2	6
TAPS-3&4	5	KAPS-1&2	3
TAPS Site*	1	KAPS Site *	1
RAPS-1&2	3	KGS-1&2	5
RAPS-3&4	6	KGS-3&4	5
RAPS-5&6	4	KGS Site*	1
RR Site*	1	KKNPP-1&2	4
MAPS-1&2	3	KK Site*	1
Kalpakkam Site*	1	RAPPCOF*	1
NPCIL- HQ	1		
IGCAR Facilities			
FBTR, KAMINI, IFSB	2	FRTG, RCL, RML	3
CORAL*			2
Total Inspections		**63**	

* Inspection covering Nuclear Security Aspects

Table 3.4: Regulatory Inspections of Industrial and Fuel Cycle Facilities and HWB HQ

Facility	No. of Inspections	Facility	No. of Inspections
IREL-HQ	1	UCIL-Turamdih Mine	1
HWP-Kota*	3	UCIL-Turamdih Mill	2
HWP-Thal	2	UCIL-Mohuldih Mine	1
HWP-Hazira	1	UCIL-Bagjata Mine	1

Facility	No. of Inspections	Facility	No. of Inspections
HWP-Manuguru	2	UCIL-Bhatin Mine	1
HWP- Manuguru*	1	UCIL-Narwapahar Mine	1
HWP-Baroda	2	UCIL-Banduhurang Mine	1
ECIL- Tirupati	1	UCIL-Tummalapalle Mine	1
UCIL-Jaduguda Mill	2	UCIL- Tummalapalle Mill	2
UCIL-Jaduguda Mine	1	IREL-Udyogamandal	2
NFC-Hyderabad	2	IREL-OSCOM	2
KMML- Chavara	1	IREL- Manavalakurichi	1
		IREL- Chavara	1
Total Inspections		**36**	

* Inspection covering Nuclear Security Aspects

3.2.2 Inspection of Headquarters (HQs) of NPCIL and IREL HQ

The inspection of NPCIL HQ is being conducted on yearly basis covering 2-3 directorates in each year. During the year 2023, inspection of the Directorate of Technical, consisting of Directorates of Engineering, Electrical and Instrumentation, Technology Development, Procurement, Reactor Safety & Analysis, and Health, Safety & Environment and Directorate of Human Resources were covered.

In-line with the inspections of NPCIL HQ, it was decided to conduct regulatory inspection of HQ of other DAE facilities (apart from NPCIL HQ) also on rotation basis to check the activities and functioning of headquarter. Accordingly, an inspection of IREL-HQ was conducted.

3.3 Regulatory Oversight of QA Activities during Manufacturing of Safety Related Reactor Equipment/Component

As a part of regulatory oversight of licensee's QA activities during manufacturing of safety related equipment/component of NPPs at vendor premises, AERB inspectors observed NPCIL activities at the premises of four vendors viz., M/s BHEL Bhopal, M/s Godrej, Dahej, M/s Walchandnagar Industries Limited (WIL) and M/s KSB, Pune and associated NPCIL Regional Centre.

3.4 Regulatory Inspection of Radiation Facilities

Radiation Facilities in the country are diverse in nature and range from diagnostic X-ray installations to proton therapy installations in the fields of medical application of radiation. Similarly, simple low activity nucleonic gauging devices to complex high activity gamma radiation processing facilities also exist in the fields of industrial application of radiation. AERB has adopted a graded approach depending on the radiation risks posed by such facilities, in its regulatory inspection programme and conducts periodic inspections under its base-line inspection programme to oversee the implementation & functioning of a radiation protection programme. Special inspections to observe type approval performance tests, commissioning tests, specific issues identified during licensing, safety review or regulatory inspection processes are also carried out in addition to reactive inspections in response to significant events and/or complaints/grievances. These inspections are conducted either as announced inspections or as unannounced inspections.

Regulatory inspection of DAE R&D facilities like BRIT, RAPPCOF, RRCAT, and VECC were carried out covering radiation protection, occupational health & safety and fire protection aspects.

This year, 942 regulatory inspections of radiation facilities were conducted which included regular inspections, special inspections, and reactive inspections. Most of the regular inspections during the third and fourth quarter of the year were conducted as unannounced inspections to know the as-is safety status of the facility and conduct of activities.

The number of inspections conducted in different type of radiation facilities are given in Table 3.5

Table 3.5: Regulatory Inspections of Radiation Facilities

Radiation Facility	Type of Inspection				Total
	Regular		Special	Reactive	
	Announced	Unannounced			
Calibration	1	3	-	-	4
Consumer Products and Scanning	2	-	8	-	10
Diagnostic Radiology	125	104	50	3	282
Gamma Irradiation Chamber	16	15	-	-	31
Gamma Radiation Processing	1	1	2	1	5
Industrial Radiography	80	111	5	2	198

Radiation Facility	**Type of Inspection**				**Total**
	Regular		**Special**	**Reactive**	
	Announced	**Unannounced**			
Industrial/Research Accelerator	6	9	14	-	29
Medical Cyclotron	5	1	-	-	6
Nuclear Medicine	85	65	1	1	152
Nucleonic Gauging Devices	2	4	-	-	6
Radiotherapy	111	82	8	4	205
Research Application	1	-	1	-	2
Sealed Sources	2	1	-	-	3
Well Logging	4	5	-	-	9
Total	**441**	**401**	**89**	**11**	**942**

CHAPTER -04

ENVIRONMENTAL SAFETY AND OCCUPATIONAL EXPOSURES

ENVIRONMENTAL SAFETY AND OCCUPATIONAL EXPOSURES

The protection of occupational worker, public and the environment is ensured through dose limitation as prescribed by AERB in its Directive No. 01/2011 under Rule 15 of the Atomic Energy (Radiation Protection) Rules, 2004. These dose limits are in line with the international standards and practices.

Environmental safety in the vicinity of nuclear installations is ensured through control on radioactive effluent discharges into the environment and elaborate environmental surveillance around the facility. These radioactive discharges are mainly in the form of liquid and gaseous radioactive effluents released during the operation of the facility. Solid waste disposal is further controlled by safe management of solid radioactive wastes and its final disposal in Near Surface Disposal Facility (NSDF). AERB issues authorization under the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 w.r.t. the volume and activity content of the radioactive effluents. AERB has also specified the requirements for safe management of radioactive wastes through AERB Safety Code titled '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 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.

4.0 Observance of Dose Limits

The exposure control consists of application of primary dose limits, action levels such as investigation level and operational restrictions. Operational restrictions are established based on dose, dose rate, air activity and surface contamination levels etc., at workplace such that the exposure of workers does not exceed the applicable dose limits. Individual exposures exceeding the investigation levels are investigated and reported to AERB. All cases of exposures exceeding the annual limits are reviewed by AERB Committee on Excessive Exposures.

The estimated dose to the members of the public due to discharge of radioactive effluents from all radiation and nuclear facilities at a site shall not exceed an effective dose of 1 mSv in a year taking into account local and regional sources as well. This is ensured through control on effluent discharges and solid waste disposal within authorised limit.

4.1 Authorised Limits of Environmental Releases/Discharge

The discharge of radioactive waste from licenced facilities is governed by the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987. It is mandatory for each licenced nuclear facility to obtain authorization under these rules from the Competent Authority for disposal of radioactive wastes and file a return annually to AERB indicating the actual quantity of radioactive waste discharged.

The operating data shows that releases from NPPs have been a small fraction of the specified release limits.

4.2 Environmental Safety

AERB has further specified limits on effluent discharges through gaseous and liquid routes in the Technical Specifications for operation of NPPs to ensure radiation dose to the members of the public at a site shall not exceed annual limit of 1 mSv (i.e. 1000 μSv). The radionuclide specific dose constraint is small fraction of the annual dose limit of 1000 μSv to the public. While specifying these constraints, it is ensured that the discharge is controlled within public exposure limit following the principles of "As Low as Reasonably Achievable" (ALARA).

It is seen that the effective dose to public around all NPP sites is far below the annual limit of 1 mSv (1000 μSv) prescribed by AERB.

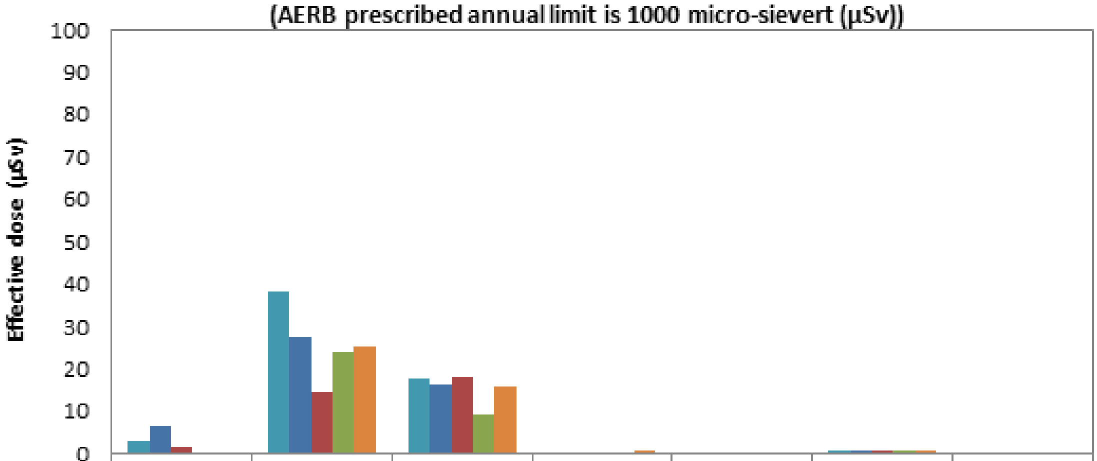
Periodic reports including information on effluent discharges are submitted by the plant sites to AERB in prescribed forms. AERB also conducts regulatory inspection of these plant sites to verify compliance with the laid down requirements. Every five years, prior to renewal of Licence for operation of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

Environmental Survey Laboratories (ESLs) of the Health, Safety and Environment Group (HS&EG), BARC, carry out environmental surveillance at all the operating NPP Sites. The liquid and gaseous radioactive wastes discharged to the environment during the year 2022 from the operating units were only a small fraction of the prescribed technical specification limits.

Radiation dose to members of the public near the operating plants is estimated based on gaseous release and measurements of radionuclide concentration in items of diets, viz. 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 a small fraction of annual limit of 1 mSv (1000 μSv) prescribed by AERB.

The effective doses to the members of the public (hypothetical person from Year 2018 to 2022) due to the release of radioactive effluents from the plants are presented in the Figures 4.1 (a) and 4.1 (b).

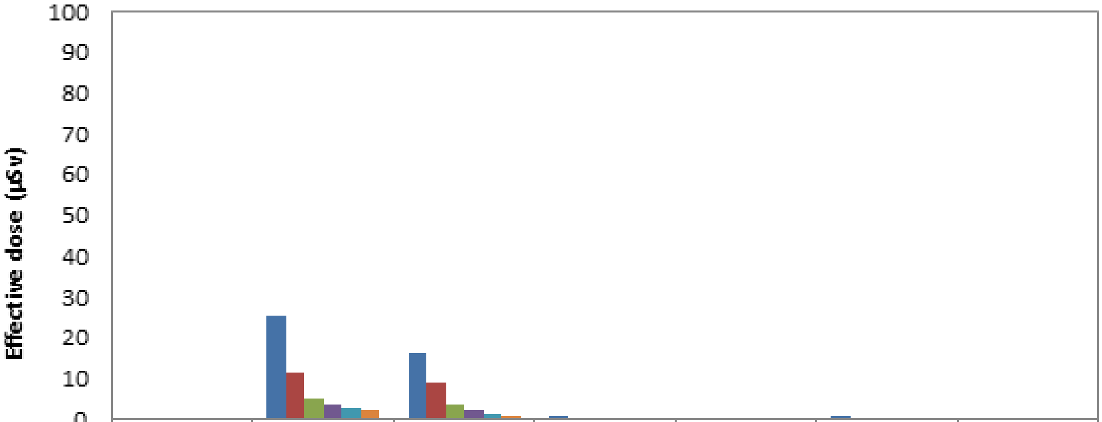
Fig-4.1 (a): Public dose at 1.6 km distance for Nuclear Power Plants during the year 2022
(AERB prescribed annual limit is 1000 micro-sievert (μSv))



	Tarapur Site	Rawatbhata site	Kalpakkam site	Narora Site	Kakrapara Site	Kaiga Site	Kudankulam site
2018	3.160	38.300	17.510	0.300	0.190	0.890	0.005
2019	6.520	27.720	16.390	0.477	0.249	0.570	0.004
2020	1.565	14.550	17.992	0.429	0.480	0.640	0.010
2021	0.235	24.140	9.377	0.506	0.210	0.970	0.003
2022	0.268	25.350	15.961	0.574	0.250	0.680	0.002

Note: 1. Public dose at Rawatbhata and Kapakkam sites are relatively higher as compared to other reactor sites due to release of Ar-41 from RAPS-2 and MAPS.
2. 1.6 km boundary for KGS site is located at 2.3 km.

Fig-4.1 (b): Total Effective Dose in different Zones during the Year 2022
(AERB prescribed annual limit is 1000 micro-sievert (μSv))



	Tarapur Site	Rawatbhata Site	Kalpakkam Site	Narora Site	Kakrapara Site	Kaiga Site	Kudankulam Site
1.6km	0.268	25.350	15.961	0.574	0.250	0.680	2.46E-03
1.6-5km	0.098	11.450	8.804	0.429	0.160	0.450	1.19E-03
5-10km	0.070	4.847	3.494	0.363	0.110	0.280	4.36E-04
10-15km	0.018	3.703	2.044	0.285	0.110	0.290	2.33E-04
15-20km	0.015	2.899	1.320	0.239	0.100	0.250	1.55E-04
20-30km	0.013	2.236	0.837	0.195	0.093	0.240	1.00E-04

Note: 1. Public dose at Rawatbhata and Kapakkam sites are relatively higher as compared to other reactor sites due to release of Ar-41 from RAPS-2 and MAPS.
2. 1.6 km boundary for KGS site is located at 2.3 km.

4.3 Occupational Exposures

4.3.1 NPPs and Nuclear Fuel Cycle Facilities

In each NPP and Nuclear Fuel Cycle Facility, a Radiological Safety Officer (RSO) and alternate RSO are designated by the Competent Authority for effective implementation of the radiation protection programme. The RSOs are entrusted with the responsibility for providing radiological monitoring of workplace, plant systems, personnel and effluent monitoring; carrying out exposure control; exposure investigations; and analysis & trending of radioactivity in plant systems.

All NPPs & Nuclear Fuel Cycle Facilities have established radiological surveillance programme and work procedures to effectively control and manage the occupational exposures within prescribed limits and ALARA. AERB Safety Manual on 'Radiation Protection for Nuclear Facilities' (AERB/NF/SM/O-2 (Rev.4), 2005) specifies Dose Limits for occupational radiation workers. As per AERB Directives, for an occupational radiation worker, annual effective dose limit is 30 mSv, with the condition that it should not exceed 100 mSv in a span of 5 years. The specified annual effective dose limit 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. The following Investigation Levels (ILs) are applicable to the nuclear facilities.

External + Internal Exposure

Monitoring Period		Exposure Level
1 month	-	10 mSv
3 months	-	15 mSv
1 year	-	20 mSv

The information on radiation dose received by workers in NPPs and Nuclear Fuel Cycle Facilities during the year 2022 is given in Table 4.1 and 4.2 respectively. In the year 2022, there was no case of individual radiation exposure above the prescribed annual dose limit. Figure 4.2 gives collective dose (Person-Sv) for operation and maintenance of NPPs for last 5 years.

Table 4.1: Radiation Doses Received by Workers in Nuclear Power Plants for the Year 2022

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 mSv
TAPS-1&2	1,010	1.17	665	1.77	1,010	NIL
RAPS-1&2	1,215	1.51	884	2.07	1,215	NIL
MAPS-1&2	1,001	0.75	775	0.98	1,001	NIL
NAPS-1&2	1,360	1.45	1,136	1.74	1,360	NIL

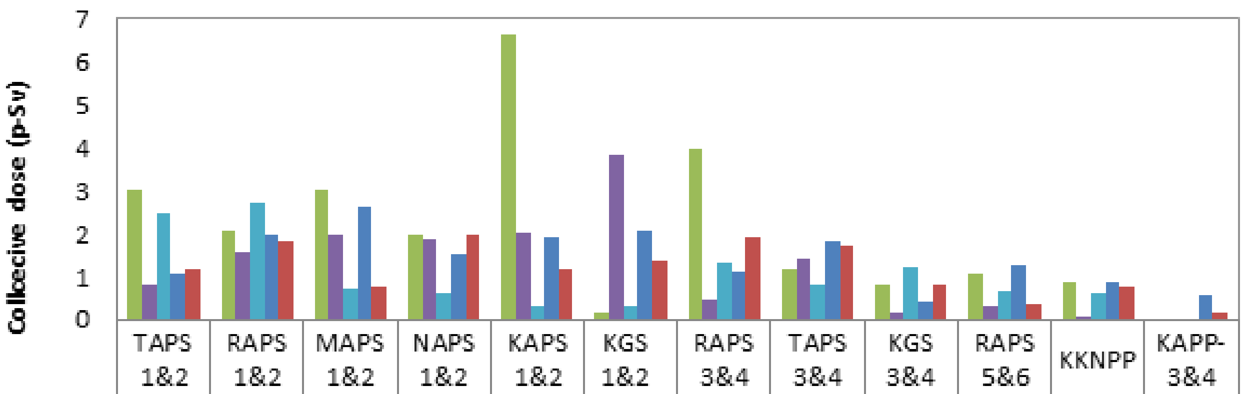
NPP	Number of Monitored Persons	Average Dose for Monitored Person (mSv)	Number of Persons Received Dose	Average Dose Among Dose Receivers (mSv)	Number of Workers Received Dose in the Range	
					< 20 mSv	>20 mSv
KAPS-1&2	1,147	1.04	741	1.61	1,147	NIL
KGS-1&2	1,239	1.11	940	1.46	1,239	NIL
RAPS-3&4	1,201	1.60	904	2.12	1,201	NIL
TAPS-3&4	1,312	1.33	971	1.80	1,312	NIL
KGS-3&4	1,207	0.66	733	1.09	1,207	NIL
RAPS-5&6	1,022	0.35	576	0.62	1,022	NIL
KKNPP-1&2	2,380	0.32	668	1.15	2,380	NIL
KAPP-3&4	2,085	0.09	501	0.37	2,085	NIL
Total	16,179	-	9,494	-	16,179	NIL

Table 4.2: Radiation Doses Received by Workers in Front End Fuel Cycle Facilities for the Year 2022

Type of facilities	Location	Number of Persons Received Dose	Average Dose Among Dose Receivers (mSv)	Maximum Dose Among Dose Receivers (mSv)	No of Workers received Dose in the range		
					<20 mSv	20-30 mSv	>30 mSv
Uranium Mines (UCIL)	Jaduguda	656	4.76	9.13	656	NIL	NIL
	Bhatin	28	2.19	3.58	28	NIL	NIL
	Narwapahar	876	3.87	6.35	876	NIL	NIL
	Bagjata	413	2.46	6.32	413	NIL	NIL
	Banduhurang	359	2.16	3.04	359	NIL	NIL
	Mohuldih	312	4.14	6.96	312	NIL	NIL
	Turamdih	583	2.78	4.76	583	NIL	NIL
	Tummalapalle	1986	4.94	10.08	1986	NIL	NIL
Uranium Mill (UCIL)	Jaduguda	852	1.48	4.17	852	NIL	NIL
	Turamdih	916	1.52	4.58	916	NIL	NIL
	Tummalapalle	791	0.50	1.71	791	NIL	NIL

Type of facilities	Location	Number of Persons Received Dose	Average Dose Among Dose Receivers (mSv)	Maximum Dose Among Dose Receivers (mSv)	No of Workers received Dose in the range		
					<20 mSv	20-30 mSv	>30 mSv
Thorium Mines and Mills (IREL)	Chavara	58	0.27	3.83	58	NIL	NIL
	Udyogamandal	159	0.785	7.47	159	NIL	NIL
	Manavalakurichi	168	1.44	10.6	168	NIL	NIL
	OSCOM	501	3.57	14.87	501	NIL	NIL
Fuel Fab. (NFC)	Hyderabad	1285	0.74	8.32	1285	NIL	NIL
	Total	9943	2.87	14.87	9943		

Fig-4.2 : Annual Collective Dose at NPPs (p-Sv)-Year 2022



	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	KAPP-3&4
2018	3.02	2.05	3.00	1.97	6.62	0.15	4	1.15	0.83	1.07	0.892	0
2019	0.83	1.57	1.97	1.85	2.04	3.81	0.45	1.41	0.18	0.34	0.07	0
2020	2.45	2.74	0.72	0.62	0.34	0.3	1.33	0.84	1.24	0.650	0.62	0
2021	1.06	1.99	2.63	1.52	1.93	2.09	1.13	1.80	0.43	1.29	0.88	0.56
2022	1.18	1.83	0.76	1.98	1.19	1.38	1.92	1.74	0.80	0.35	0.77	0.18

4.3.2 Radiation Facilities

In each Radiation facility, a Radiological Safety Officer(s) (RSO) is designated by employer and approved by the Competent Authority. The RSO is entrusted with the responsibility for providing radiological surveillance and safety support functions. These include radiological monitoring of workplace & personnel, effluent monitoring (in handling of open sources), excessive exposure investigation etc.

The radiation doses received by workers in medical, industrial and research institutions for year 2022 are given in Table 4.3.

Table 4.3: Radiation Doses Received by Workers in Medical, Industrial and Research Institutions for the Year 2022

Category of Radiation Worker	No. of Monitored Persons	Average Dose for Monitored Persons (mSv)	No. of Persons Received Dose	Average Dose among Dose Receivers (mSv)	No. of Workers Received Annual Individual Dose excluding Zero Dose (mSv)				No. of Persons who Received Cumulative Dose > 100 mSv during 5-Year Block (2017 to 2021
					0<D ≤20	20<D≤30	30<D≤50	D>50	
Diagnostic X-rays	1,62,003	0.25	44,271	0.91	44,224	42	3	2	17
Radiation Therapy	16,730	0.14	3,742	0.64	3,741	1	0	0	0
Nuclear Medicine	2,829	0.54	1,349	1.14	1,346	3	0	0	0
Industrial Radiography	8,523	0.26	1,672	1.32	1,681	1	0	0	6
Radiation Processing Facility	540	0.18	95	1.02	95	0	0	0	0
Research	4,217	0.12	772	0.64	771	1	0	0	0
Total	1,94,842	0.24	51,911	0.90	51,858	48	3	2	23

For better exposure control, individual cases are investigated and controlled at an early stage so as to remain within the AERB specified dose limits. However, any person exceeding 10 mSv in a monitoring period is investigated to establish the root cause, work practice and assignment of dose.

4.4 Initiatives Taken by AERB for Dose Reduction

4.4.1 Review of Radiation Protection Aspects during Project Stage

During design and commissioning stages, it is ensured that an elaborate radiation monitoring system comprising of area radiation monitors, process monitors, environmental monitors and effluent monitors are in place. This enables to retrieve history, trend and instantaneous readings of the parameters for exposure control.

4.4.2 Operation Phase

Radiation protection programme during the operation of facility is periodically revised by the facility which is subsequently reviewed and approved by AERB. This programme comprises of organizational, administrative and technical elements. ALARA measures are put in place for exposure control of the plant personnel and the public. AERB reviews arrangements made by plant management for implementation and effectiveness of the radiation protection programme. RSO for each Nuclear Facility is authorized by AERB, who carries out radiological safety functions.

The environmental surveillance programme is also reviewed to evaluate the impact of operation of the NPP on the surrounding areas of the plant site and to ensure that effluent releases and public exposures are below the regulatory limits.

4.4.3 Collective Radiation Dose Budgeting

Collective Dose Budget (CDB) is prepared by each facility annually on the basis of jobs (having potential of radiation exposures) that are likely to be executed, anticipated collective dose in these jobs, collective dose consumed in the previous years as well as the existing radiological conditions, benefits accrued by design improvements, identification of improvements based on operating experience and corrective actions taken etc. The aim is to optimize the collective dose through ALARA principle. AERB carries out review of the CDB. Dose incurred in any unplanned activity is to be recorded as unanticipated dose which is discussed for justification prior to approval of the same by AERB.

4.4.4 Review of Radiological Safety Aspects

Routine quarterly and annual reports on radiological safety aspects are prepared by the RSO of the facility and periodically submitted to AERB. These reports are reviewed at AERB and necessary corrective measures as required for exposure control are recommended to respective facility. In addition, exposure investigation reports, significant event reports (radiological aspects) are also reviewed and corrective actions are recommended. The compliance to radiological safety aspects are also verified through routine inspection and special inspections.

4.4.5 Exposure Control and Implementation of ALARA

AERB ensures that all nuclear facilities have radiation safety programmes and work procedures intended to control the occupational exposures. Exposures to Site personnel are controlled by combination of radiation protection measures such as:

i. All NPPs and nuclear fuel cycle facilities have ALARA Committees at Station and sectional level. Periodic ALARA reviews are conducted at the NPPs to identify areas for dose reduction and to implement corrective actions.
ii. The operating experiences on radiological events at NPPs in India and in other countries are reviewed and the lessons learned are communicated to all concerned.
iii. Programme of collective dose budgeting.
iv. Restricting the external exposure by means of shielding, remote operation, source control, rehearsing the work on mock-ups and minimizing the exposure time.
v. Minimizing the internal exposures by source control.
vi. Periodic review of radioactive work practices.
vii. Periodic training of radiation workers on radiation protection aspects, and
viii. Trending and analysis of radiological data.

CHAPTER -05

EMERGENCY PREPAREDNESS

EMERGENCY PREPAREDNESS

Nuclear Power Plants (NPP) in India are designed, constructed, commissioned and operated in conformity with relevant nuclear and radiation safety requirements. These requirements ensure an adequate margin of safety so that NPPs can be operated without undue radiological risks to the plant personnel, members of the public and the environment. State of the art safety measures are provided based on principles of defence-in-depth, redundancy (more numbers than required) and diversity (back-up systems operating on different principles). In addition, it is mandatory to develop Emergency Preparedness and Response (EPR) plans and to conduct periodic exercises to test these plans. These plans are prepared in accordance with the national laws, rules and regulations for effective management of any eventuality with a potential to pose an undue radiological risk to the plant personnel and public.

EPR plans are also required for non-nuclear facilities that are under the purview of AERB and handling hazardous chemicals viz. Heavy Water Plants (HWP) based on ammonia and hydrogen sulphide and other heavy water facilities catering to the production of solvents. These EPR plans are prepared as per AERB Safety Guidelines and the Manufacture, Storage and Import of Hazardous Chemical Rules, 1989 for On-Site and Off-Site Emergency Preparedness for non-nuclear installations and deal with the effective management of any eventuality with a potential to pose an undue chemical risk to the plant personnel and public.

The establishment and submission of emergency preparedness plans and procedures is one of the pre-requisites for licensing of nuclear and radiation facilities.

5.0 Role of AERB in Emergency Preparedness and Response

AERB has established regulations and guidelines specifying the principles, requirements and associated guidance and criteria for EPR for response organizations. It also ensures and verifies that arrangements for preparedness and response to a nuclear and radiological emergency for facilities and activities under purview of licensee are adequate. This is achieved by review and approval of the EPR plans (plant, site and off-site) of the licensee, review of plans of district authority and oversight of the arrangements and preparedness of the licensee through regulatory inspection and observation of emergency exercises. During an emergency, AERB's role is to keep itself apprised of the situation, review of response actions and inform public as and when necessary. These EPR plans are periodically tested for their effectiveness through well coordinated exercises involving various stakeholders.

5.1 Review of Emergency Preparedness and Response Plans

During the year, NPPs and other non-nuclear facilities conducted periodic emergency exercises. Plant Emergency Exercise (PEE), Site Emergency Exercise (SEE) and Off-site Emergency Exercises (OSEE) were carried out as per approved frequency. PEEs were conducted by NPPs with the frequency of once in every quarter. SEEs were conducted at all NPP sites following the frequency of once in a year. OSEE was carried out as per the revised off-site emergency exercise framework. During the year, EPR plans of KGS 1&2 and KGS 3&4 were approved.

5.2 Framework for Conduct of Off-Site Emergency Exercises

The existing requirements and arrangements for preparedness and response to nuclear and radiological emergency (NRE) takes into account current international standards, lessons learned from the Fukushima accident w.r.t Emergency Preparedness and Response (EPR) and inputs/ feedbacks from all stakeholders.

AERB recently adopted a revised scheme for conducting off-site emergency exercises. The scheme includes Table-Top (TT) exercise, Integrated Command Control and Response (ICCR) exercise and Field Exercise and Demonstration (FED). It also includes consulting and obtaining feedbacks from the stakeholders (NDMA, CMG-DAE, NPCIL, HSEG-BARC and AERB).

In TT exercises, the emphasis is on testing the decision-making capability of plant authorities to declare emergency and evolve protection strategy based on plant conditions to recommend protective actions.

In ICCR exercises, the emphasis is on decision-making process, command control functions, early warning and field response, resource mobilization, inter-agency co-ordination, and communication. The exercise involves activation of Plant/Site Authorities, District Authorities, Crisis Management Group –DAE (CMG-DAE) & DAE- Radiation Emergency Response Director (DAE-RERD). These exercises (TT and ICCR) are to be conducted in a realistic environment where the information on the event and possible consequence will not be known to the response organizations participating in the exercises.

In FED exercise, field response and protective measures in public domain are tested.

Table 5.1: Framework for conduct of Off-Site Emergency Exercises at NPP Sites

Type of Exercise	Frequency	Responsible Agency	Oversight
Table Top (TT) Exercise	In every two years for each Station and within 6 months of a new Site Director/Station Director (in twin-unit site) taking charge	NPP *	AERB
Field Exercise and Demonstration (FED)	Once every year and all Habitable Sectors to be covered over a period of 8 years.	District Authority * (Supported by NPP for Planning and Technical Inputs)	NDMA
Integrated Command Control and Response (ICCR)	Every 3 years for each NPP Site The date of conduct of Exercise shall be chosen such that Exercises cover different Seasons and Metrological Conditions	NPP* & District Authority, CMG-DAE, RERD	AERB & NDMA

* Prime Responsibility for conduct of exercises

The framework for conduct of Off-Site Emergency Exercises (Table 5.1) was finalised after consulting the stakeholders and with requisite review at AERB.

5.3 Emergency Exercises at NPPs

The NPPs have started conducting Off-Site Emergency Exercises as per the new framework. During the year, the Table-Top OSEE was conducted at five NPPs viz. TAPS 3&4, KGS 3&4, NAPS 1&2, KKNPP 1&2 and MAPS 1&2. AERB officials observed these exercises at the NPP sites. Decision making capabilities and response actions by Plant/Site Authorities were observed. Nuclear and Radiological Emergency Monitoring Centre (NREMC) at AERB was also activated. The progression of event, response actions and recommended protective actions were monitored and assessed.

The number of SEE and OSEE conducted at various NPP Sites in 2023 are listed in Table 5.2.

Table 5.2: Site and Off-Site Emergency Exercises at NPP Sites for the Year 2023

NPP Sites	SEE	OSEE (Table-Top)
Tarapur	1	1 (TAPS 3&4)
Rawatbhata	1	-
Kalpakkam	1	1 (MAPS 1&2)
Narora	1	1 (NAPS 1&2)
Kakrapar	1	-
Kaiga	1	1 (KGS 3&4)
Kudankulam	1	1 (KKNPP 1&2)
Total	7	5

Table-Top Off-Site Emergency Exercise

Table-Top Off-Site Emergency Exercise

5.4 Nuclear and Radiological Emergency Monitoring Centre at AERB

During nuclear and radiological emergency, AERB monitors and keeps itself informed about the emergency situations. It reviews & assesses the emergency situations and informs the public and the Government on the safety significance of events and actions being taken as and when required. To facilitate this, AERB has instituted an Emergency Response Monitoring Organization (ERMO). The activities of ERMO are carried out and coordinated by the Nuclear and Radiological Emergency Monitoring Centre (NREMC) established at AERB. The Centre has various cells for communication, assessment, analysis and public information along with necessary software and hardware infrastructures.

The capabilities of NREMC include accident analysis, assessment of emergency response actions & protective actions and communication with Stakeholders. The resources related to software systems with on-line Decision Support System (DSS), source term and radioactivity release assessment, environmental monitoring data inputs, video conferencing with other emergency response agencies and trained & experienced personnel have been established. NREMC is kept on alert mode during any abnormal natural phenomena occurring in any of the districts containing NPPs and subsequently activated as required. Further during plant and site emergency exercise conducted by NPP sites, NREMC is poised to receive information about the on-going exercises. In case of OSEE at NPP Site, NREMC is activated and its various functions are tested including independent assessment. In case of real emergencies, NREMC is activated as per the established plans and procedures.

During the year, NREMC was activated during the conduct of Off-Site Emergency Exercises at various NPP sites. The functioning of NREMC during the Off-Site Exercise serves the dual purpose of monitoring the response action executed by the Licensee and other response agencies during the exercise by carrying out independent assessment and verification and for testing the plans and procedures established at AERB for monitoring an emergency response.

CHAPTER -06

REGULATORY SAFETY DOCUMENTS

REGULATORY SAFETY DOCUMENTS

One of the core activities of AERB is to develop the safety regulation for different types of facilities and activities under its purview. Development and revision of Regulatory Safety Documents (Safety REGDOCs) is a continual process of AERB taking into account national requirements, international developments and good practices.

The process of Safety REGDOC development takes into account the following aspects:

- Inputs from Safety Reviews / Legal Views / Technical Discussions
- Requirements identified during consenting, regulatory inspection and enforcement process
- New regulatory and technological developments relevant to AERB
- International Practices
- Specific aspects of recommended/ accepted practices
- Experience/feedback from nuclear and radiation facilities

Safety REGDOCs issued by AERB are classified as follows in descending order of hierarchy:

- Safety Codes/ Safety Standards
- Safety Guides
- Safety Manuals

Pictorial representation of hierarchy of safety documents is given in Figure 6.1.

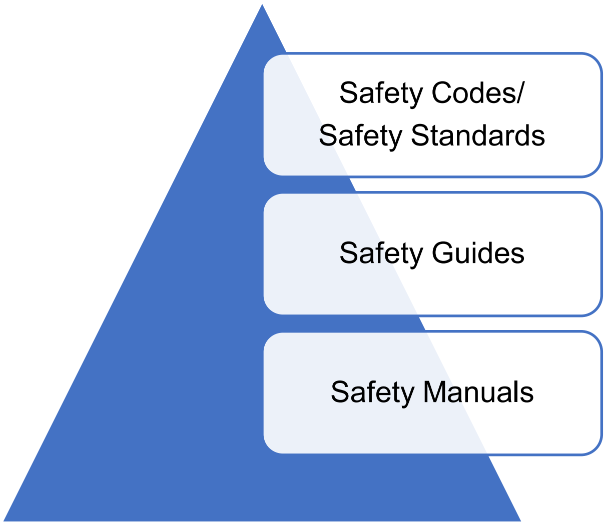


Fig.6.1 Hierarchy of Safety Documents

Safety codes and safety standards establish the objectives and set requirements that shall be fulfilled to provide adequate assurance for safety. Safety guides elaborate various requirements and furnish approaches for their implementation. Safety manuals deal with specific topics and contain detailed scientific / technical information on the subject.

AERB has issued safety documents, which provide adequate coverage commensurate with the radiation risks associated with the facilities and activities. Till date, AERB has published 153 Safety REGDOCs which include Safety Codes, Standards, Guidelines, Guides and Manuals.

6.0 Regulatory Safety Documents Development Process

AERB has an established process for development and revision of Safety REGDOCs. The process of development of new or revision of old Safety REGDOCs begins with Safety Document Development / Revision Proposal (SDDP / SDRP). It is prepared by technical staff of AERB based on the requirements emanated from the review of inputs from various regulatory processes, operating experience, among others.

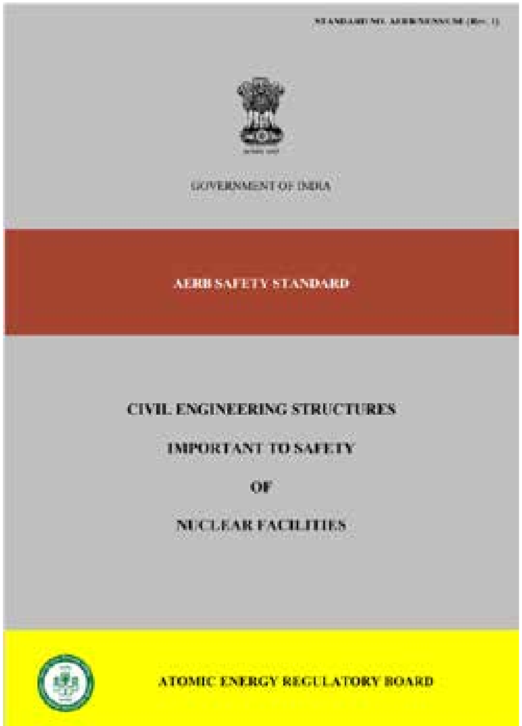
As per the approved SDDP, the initial draft of the REGDOC is prepared in-house in AERB and is reviewed by Task Force constituted for this purpose. Technological advances, R&D work, relevant operational lessons learned and institutional knowledge are considered as appropriate in development/revision of the Safety REGDOCs. The development and revision process also involves participation of experts and stakeholders by direct involvement as well as through comments and feedback. The draft is also reviewed by respective standing committees and apex committee based on graded approach.

Advisory Committee on Nuclear and Radiation Safety (ACNRS), an apex committee, supports AERB in the review of draft regulatory documents and safety issues. ACNRS consists of senior experts in the areas relevant to nuclear & radiation safety and its regulation.

After technical and copy editing, the draft is approved by Chairman, AERB for publication. In case of Safety Codes and Safety Standards, legal vetting is done and public comments are also sought on the draft before its finalization. Subsequently the draft is reviewed and approved by the Board of AERB.

6.1 Regulatory Safety Documents Developed/Revised

In 2023, AERB published a Safety Standard on "Civil Engineering Structures Important to Safety of Nuclear Facilities AERB/NF/SS/CSE (Rev. 1) "
The Safety Standard specifies the analysis and design requirements of civil engineering structures important to safety in order to achieve safe operation of NFs. It also sets out requirements to be fulfilled during construction, commissioning, operation, decommissioning as well as margin assessment of civil engineering structures.



6.2 Safety Documents under Development / Revision

Safety documents on various topics are being developed/revised. The documents under development/revision are as follows:

Safety Codes

1. Safety Code on 'Radiation Sources, Equipment & Installations' (AERB/SC/RF)
2. Safety Code on 'Regulation of Nuclear and Radiation Facilities' (AERB/SC/G)
3. Safety Code on 'Design of Sodium Cooled Fast Reactor based NPPs' (AERB/NPP-SFR/SC/D)
4. Safety Code on 'Design of Pressurised Heavy Water Reactor based Nuclear Power Plants (AERB/NPP-PHWR/SC/D (Rev. 1))
5. Safety Code on 'Quality Assurance in Nuclear Power Plants' (AERB/NPP/SC/QA (Rev.1))

Safety Standards

6. Safety Standard on 'Fire Protection Systems for Nuclear Facilities' (AERB/NF/SS/FPS (Rev. 1))

Safety Guides

7. Safety Guide on 'In Service Inspection of NPPs' (AERB/NPP/SG/O-2)
8. Safety Guide on 'Consenting Process For Nuclear Power Plants And Research Reactors' (AERB/NPP&RR/SG/G-1)
9. Safety Guide on 'Consenting Process For Nuclear Fuel Cycle Facilities And Related Industrial Facilities Other Than Nuclear Power Plants And Research Reactors' (AERB/NF/SG/G-2)
10. Safety Guide on 'Design Basis Flood for Nuclear Power Plants on inland sites' (AERB/SG/S-6A (Rev.1))
11. Safety Guide on 'Safety Classification and Seismic Categorisation for Structures, Systems and Components of Pressurised Heavy Water Reactors' (AERB/NPP-PHWR/SG/D-1)
12. Safety Guide on 'Fuel Design for Pressurised Heavy Water Reactors' (AERB/SG/NPP-PHWR/D-6)
13. Safety Guide on 'Primary Heat Transport System for Pressurised Heavy Water Reactors (AERB/NPP-PHWR/ SG/D-8)
14. Safety Guide on 'Radiation Protection Aspects in Design for Pressurised Heavy Water Reactor Based Nuclear Power Plants' (AERB/NPP-PHWR/SG/D-12)
15. Safety Guide on 'Deterministic Safety Analysis for Pressurized Heavy Water Reactors '(AERB/NPP-PHWR/SG/D-19)
16. Safety Guide on 'Deterministic Safety Analysis for Sodium Cooled Fast Reactor based NPPs' (AERB/NPP-SFR/SG/D-19)
17. Safety Guide on 'Containment System Design for PHWRs' (AERB/NPP-PHWR/SG/D-21)
18. Safety Guide on 'Design of Fuel Handling and Storage Systems for Pressurised Heavy Water Reactors (AERB/SG/D-24)
19. Safety Guide on 'Computer Based Systems of Pressurised Heavy Water Reactors' (AERB/NPP-PHWR/SG/D-25)
20. Safety Guide on 'Level 1 Probabilistic Safety Assessment (PSA) for NPPs' (AERB/NPP/SG/D-28)
21. Safety Guide on 'Level 2 Probabilistic Safety Assessment (PSA) for NPPs' (AERB/NPP/SG/D-29)
22. Safety Guide on 'Staffing, Recruitment, Training, Qualification and Certification of Operating Personnel of Nuclear Power Plants' (AERB/SG/O-1)
23. Safety Guide on 'Operational Limits and Conditions for Nuclear Power Plants' (AERB/SG/O-3)
24. Safety Guide on 'Commissioning Procedures for Pressurised Heavy Water Reactor based Nuclear Power Plants' (AERB/SG/O-4)

25. Safety Guide on 'Commissioning of Sodium Cooled Fast Reactor Based Nuclear Power Plants' (AERB/SG/O-4D)
26. Safety Guide on 'Surveillance of Items Important to Safety in Nuclear Power Plants' (AERB/SG/O-8)
27. Safety Guide on 'Management of NPPs for Safe Operation' (AERB/SG/O-9)
28. Safety Guide on 'Quality Assurance In Nuclear Facilities' (AERB/SG/MS)
29. Safety Guide on 'Management of Nuclear and Radiological Emergencies in Nuclear Facilities' (AERB/NF/SG/NRE-1)
30. Safety Guide on 'Management of Emergency Arising From Radiation Sources, Equipment And Installation' (AERB/RF/SG/NRE-2)
31. Safety Guide on 'Management of Nuclear And Radiological Emergencies during Transport of Radioactive Material' (AERB/NF/SG/NRE-3)
32. Safety Guide on 'Industrial Radiography' (AERB/RF/SG/IR)
33. Safety Guide on 'Industrial Accelerator Radiation Processing Facility' (AERB/RF/SG/IARPF)
34. Safety Guide on 'Container Scanner' (AERB/RF/SG/CS)
35. Safety Guide on 'Diagnostic Radiology' (AERB/RF/SG/DR)
36. Safety Guide on 'Nucleonic Gauges' (AERB/RF/SG/NG)
37. Safety Guide on 'Well logging Applications' (AERB/RF/SG/WL)
38. Safety Guide on 'Medical Cyclotron Facilities' (AERB/RF/SG/MCF (Rev.1))
39. Safety Guide on 'Gamma and X-ray Irradiation Chamber' (AERB/RF/SG/GXIC)
40. Safety Guide on 'Gamma Radiation Processing Facility' (AERB/RF/SG/GRAPF)
41. Safety Guide on 'Particle Accelerator Research Facility' (AERB/RF/SG/PARF)
42. Safety Guide on 'Manufacture and Supply of Consumer Products' (AERB/RF/SG/CP)
43. Safety Guide on 'Use Of X-ray Generating Equipment In Research, Education, Inspection And Analysis' (AERB/RF/SG/XGE)
44. Safety Guide on 'Radiation Therapy' (AERB/RF/SG/RT)
45. Safety Guide on 'Nuclear Medicine' (AERB/RF/SG/NM)
46. Safety Guide on 'Radioactive Sources used Research, Education, Inspection and Analysis' (AERB/RF/SG/RS)
47. Safety Guide on 'Medical Management of Persons Exposed In Radiation Accidents' (AERB/NRF/SG/MED-1(Rev.1))

Safety Manuals

48. Safety Manual on 'Radiation Protection for Nuclear Facilities', (AERB/NF/SM/O-2, (Rev.4))
49. Safety Manual on 'Management of Radioactive Wastes Arising From Nuclear Medicine Facilities' (AERB/RF/SM/RW-1)
50. Safety Manual on 'Methodology For Radiological Impact Assessment For Public Dose Computation and Dose Apportionment Due To Operational States of Nuclear Facility'(AERB/SM/RIA-2)
51. Safety Manual on 'Radiation Protection For Radiation Facilities' (AERB/RF/SM/O-2)
52. Safety Manual on 'Hydrogen Release and Mitigation Measures under Accident Conditions in Pressurised Heavy Water Reactors (With Amendment)' (AERB/NPP-PHWR/SM/D-2)

6.3 Review of Draft IAEA Safety Documents

AERB reviews draft IAEA safety documents and provides its perspective to IAEA. In 2023, AERB experts reviewed 19 IAEA Draft Standards (DS) and 11 IAEA Document Preparation Profile Draft Standards (DPP DS).

CHAPTER -07

SAFETY ANALYSIS AND RESEARCH

SAFETY ANALYSIS AND RESEARCH

AERB recognizes the importance of Safety Analysis & Research in support of its regulatory functions. In-house safety related R&D helps in obtaining deeper insights into the issues concerning nuclear and radiation safety to arrive at technically sound regulatory decisions. Safety analysis and research activities are carried out by AERB as a part of its regulatory activities. Brief overview of several important developmental studies taken up by AERB during this year is presented in the following sections.

7.1 Reactor Thermal Hydraulics Safety Studies

7.1.1 Studies on Sodium Aerosol Characteristics in SFR Cover Gas Region

In Sodium-cooled Fast Reactors (SFR), due to the reactive nature of sodium, provision of an inert isolation layer (known as cover gas space) is provided above the primary sodium boundary. During reactor operation, sodium aerosols are generated continuously via sodium evaporation and transported to the cover gas space. Understanding the evolution and transport of sodium aerosols within the cover gas is of paramount importance for comprehending their dynamics under various reactor-operating conditions. A detailed CFD model of the cover gas geometry of SILVERINA facility available at IGCAR was developed in Open FOAM framework. This study was useful for validation of the numerical model and subsequently for development of a correlation to predict the aerosol mass concentration as a function of temperature difference between roof slab and sodium pool. The present model can be used to obtain inputs for radiological impact assessment. The variation of aerosol mass concentration in the cover gas region is shown in Fig. 7.1.1 (a) and (b).

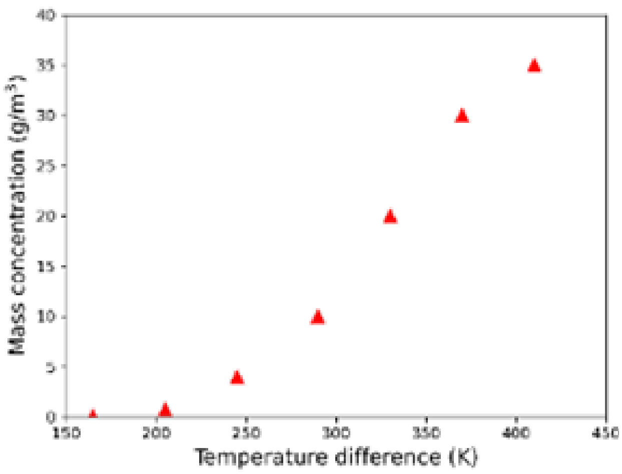


Fig. 7.1.1 (a) Mass Concentration vs. Temperature Difference between Roof-Slab Bottom Plate Temperature and Sodium Tool Temperature

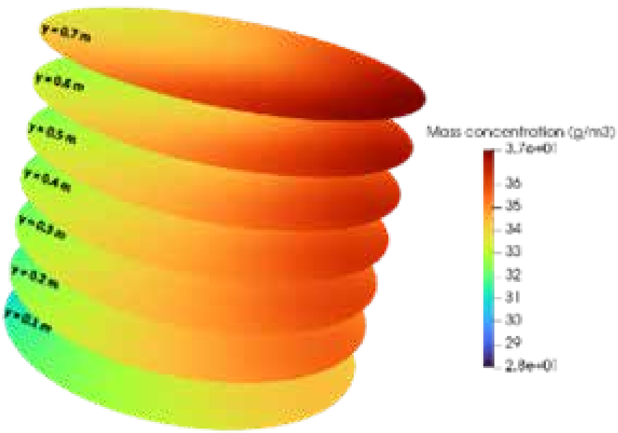


Fig. 7.1.1 (b) Mass Concentration Variation along Height for Operating Conditions (Pool Temperature: 823 K and Roof Temperature: 413 K)

7.1.2 CFD Simulation of Temperature Distribution in KAPP 3 Containment

The objective of this study was to calculate the overall heat/temperature distribution inside 700 MWe PHWR containment due to the heat released from Feeder Header Insulation Cabinet (FHIC) and other sources and to assess the efficacy of the ventilation system. For a given ventilation system configuration in 700 MWe PHWR containment, a model has been developed in CFD code. The detailed configuration of FHIC, coolers, fans and insulation system has been considered in model. For 50% power case and given cooler and fan capacity, CFD simulation was performed to estimate the containment temperature distribution and results were compared with the measured plant data. It was observed that CFD model is closely matching the actual temperature in the containment with the given heat loss conditions. The temperature distribution in the containment for the FM vault plane is shown in Fig.7.1.2. It shows the different high temperature zone as well as effect of the ventilation system on temperature distribution.

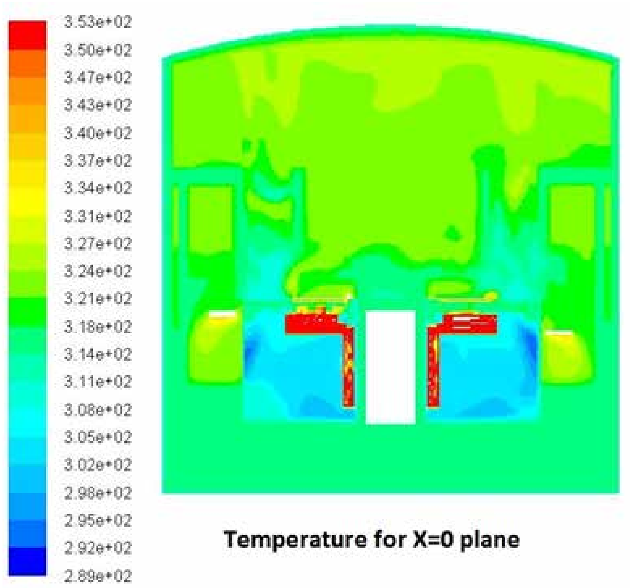


Fig.7.1.2: Temperature Distribution FM Vault Plane

7.2 Severe Accident Studies

7.2.1 Critical Heat Flux on PHWR Calandria during Severe Accident

A comprehensive hydrodynamics model based on two-phase boundary layer flow was developed to obtain critical heat flux (CHF) on calandria outer surface. The objective was to assess the thermal margin available for success of In-Vessel Retention (IVR) strategy, which is considered to be a key severe accident management option in PHWRs. The model was benchmarked using experimental data from three facilities, namely ULPU-III, SBLB and BARC facility for curved section of PHWR calandria vessel reported in literature. It was then applied for estimating CHF on PHWR-700 calandria vessel outer surface for a scenario involving LOCA followed by loss of all heat sinks. Similar studies were undertaken for PHWR-220 calandria vessel. Several parametric studies were also conducted to bring out the effect of vessel size, system pressure, sub-cooling of vault water and depth of submergence of vessel on CHF. The model was then applied to estimate CHF on PHWR-700 calandria tube outer surface under the same accident condition.

7.2.2 Numerical Studies on In-Vessel Corium Retention in PHWR-700 during Severe Accident Conditions

A numerical model is developed using Open FOAM CFD software to study the core melting and solidification process in the calandria vessel following a postulated severe accident scenario. The model uses finite volume method for obtaining the solution. Convection and radiation boundary conditions are applied on the top of corium region. On the vessel bottom, suitable boiling heat transfer correlations are used to capture the crust formation. Heat transfer to inner surface of calandria vessel is analysed in detail.

Fig. 7.2.2 (a) shows the temperature distribution in corium melt pool and calandria vessel under steady state conditions. Velocity distribution in the molten region of the pool is shown in Fig. 7.2.2 (b). This study has provided additional inputs for assessing the thermal margin available for in-vessel retention (IVR) in calandria.

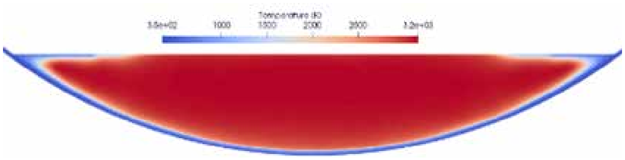


Fig. 7.2.2 (a) Temperature Distribution in Corium Melt Pool and Calandria Vessel

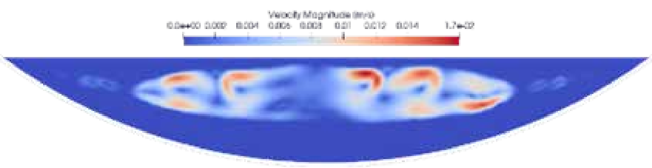


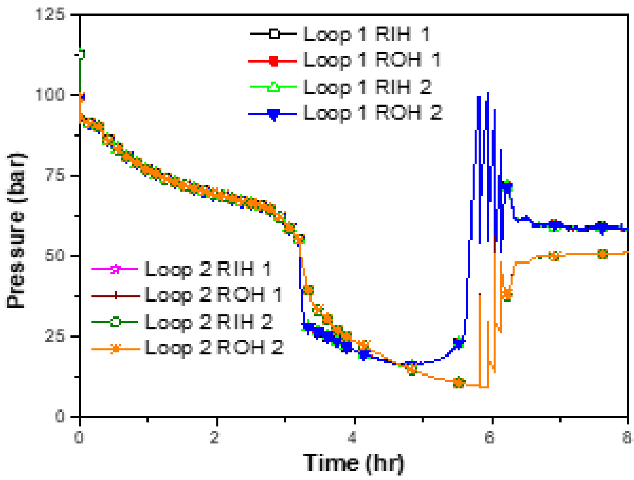
Fig. 7.2.2 (b) Velocity Distribution in the Molten Region of Pool

7.2.3 Analysis of Extended Station Blackout Scenario in Spent Fuel Pool of PHWRs

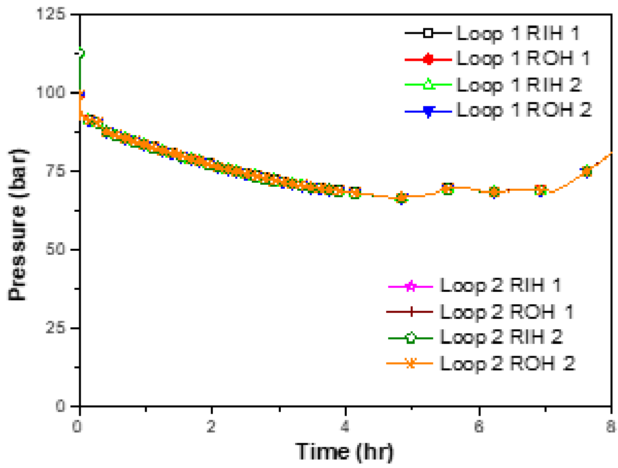
In a PHWR, spent fuel bundles are stored underwater in trays that are stacked in the form of racks. The spent fuel pool water removes decay heat and provides shielding against radiation. The capability of PHWR spent fuel pool (SFP) for heat removal was assessed for an extended station blackout scenario without considering any mitigating actions. It was assumed that the SFP is loaded to the maximum extent, with spent fuel discharged over a period of 10 years together with one full core unload. As per analysis, the time available for preventing thermal transient and chemical oxidation in fuel bundles is around 10 days. The results compare well with utility submission on evaporation rate and fall in water level.

7.2.4 Transients under Non-availability of One or More PDHRS Banks

The effect of non-availability of one or more PDHRS, of PHWR-700MWe, during a Station Blackout (SBO) event was investigated using RELAP5/Mod 3.4. Failures of one PDHRS in one loop and failure of one PDHRS in each of the loops were considered, with different valve-in times, to examine their influence on thermal-hydraulic transients. It was found that oscillations in the primary loop were effectively mitigated when there was a simultaneous failure of one PDHRS in both the loops. This was in contrast to oscillations



(a) Failure of one PDHRS in one Loop



(b) Failure of two PDHRS, one in each Loop

Fig. 7.2.4: Variation of PHT Header Pressure

observed in the case of failure of one PDHRS in a single loop. The symmetrical operation during simultaneous failure of two PDHRS appears to prevent instabilities and flow reversals during the transient phase. Fig. 7.2.4 depicts the variation in PHT pressure.

7.2.5 Disassembly Phase Analysis for a Medium Sized MOX Fuelled SFR

A coupled neutronics-hydrodynamics compute code is developed to model the super-prompt critical power excursion during disassembly phase of Core Disruptive Accident (CDA) in a fast reactor. This computer code has been developed to provide an estimate of the thermal energy released and work potential during the disassembly phase of CDA in a medium sized MOX fuelled Sodium Cooled Fast Reactor (SFR). The code is validated against a severe transient event in the Fast Flux Test Facility (FFTF) reactor. It is then applied to study disassembly phase in a typical medium sized MOX fuelled SFR . Fig. 7.2.5 (a) and (b) show the evolution of thermal power and energy for voided and non-voided core states respectively. Termination of the transient occurs early in the case of non-voided core due to faster rate of negative reactivity insertion. The code has capability to predict peak pressure, thermal energy and the work potential for the disassembly phase.

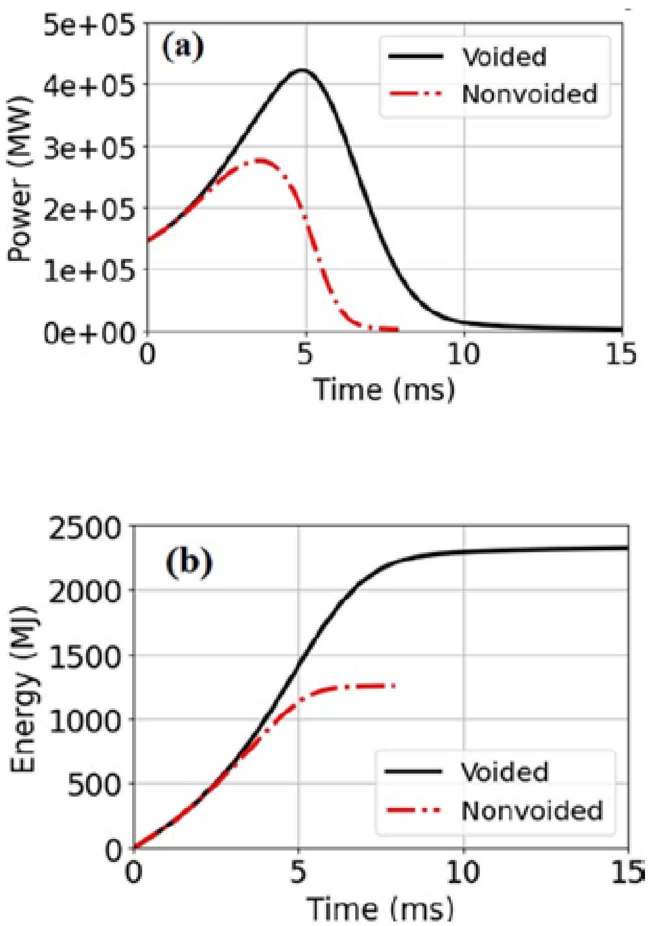


Fig.7.2.5: Variation of (a) Power and (b) Energy during Disassembly Phase in a Medium sized MOX Fuelled SFR for fully Sodium Voided and Non-voided Core States

7.3 Safety Analysis Code Development & Benchmarking

7.3.1 Analysis of End Fitting Failure Event during Fuel Handing Operation in PHWRs

A fuel handling accident condition is postulated in which the fuelling machine disengages without the seal plug being properly fixed on the coolant channel resulting in ejection of all the 12 fuel bundles from the coolant channel on the FM vault floor. These bundles generate decay heat as per their operating history but experience loss of cooling resulting in increase in temperature. This event was analysed in detail using in-house developed computer program called SAAP. The fuel bundle initial temperature corresponds to full power operating conditions for the highest rated channel. Heat loss by radiation and natural convection are considered. Numerical studies have shown that 8 out of 12 fuel bundles could experience high temperature transients and clad failure. The maximum clad temperature reached is around 1500°C for the central pin of highest rated bundle as shown in Fig.7.3.1. Under

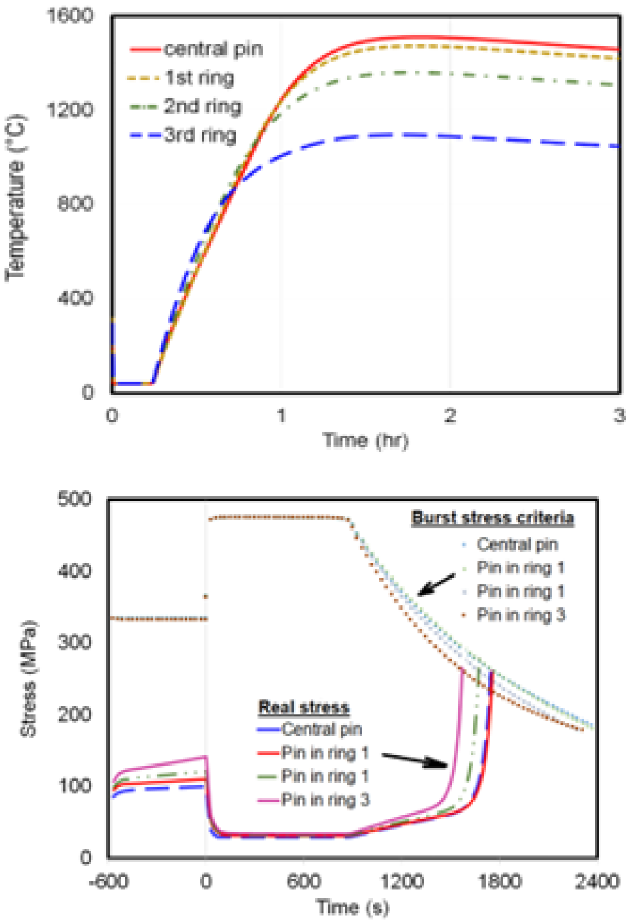


Fig. 7.3.1: Temperature Transients in Fuel Pin and failure by Burst Stress Criteria for the Highest Rated Fuel Bundle

unlimited steam condition, around 720g of H_2 is generated from all the ejected fuel bundles.

7.3.2 Thermal Qualification of Type B (U) Cask

Numerical techniques required for thermal qualification of radioactive material transport cask to satisfy regulatory requirements has been shown by a detailed study. A typical type B(U) fuel bundle cask was selected for analysis. Type B(U) casks contain materials with reasonably high levels of radioactivity, such as spent fuel, high concentration of certain radioisotopes such as ^{137}Cs, cobalt sources etc. The focus of this study was to (a) outline the methods needed to capture melting and solidification of shielding lead during fire and post fire transients and (b)

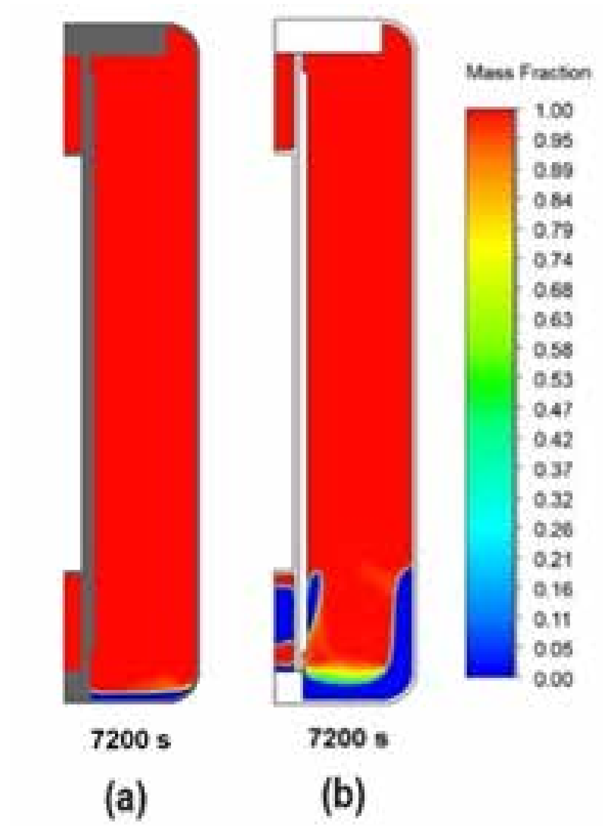


Fig.7.3.2: Commencement of Solidification at the bottom of the Cask; (a) Hydrocarbon-air Curve, (b) Constant 800°C Fire

bring out the role played by choice of fire curve and cask surface boundary conditions on the transients. The study covers simulation of normal transport conditions, followed by fire and post-fire transient analysis. Initial temperature of cask is taken same as ambient temperature. Half an hour fire exposure conditions were simulated using boundary conditions in the form of hydrocarbon fuel-air fire, ISO-834 curve as well as considering constant 800°C surrounding temperature. During the hydrocarbon fuel-air fire test, lead is found to melt before the completion of the test whereas for the 800°C case, only 69.7% of lead had melted. Solidification process begins at the bottom of the cask during cool-down phase. Solidification begins earlier for the constant 800°C case. Fig.7.3.2 show contour plots of solidified lead for two cases. This study is intended to provide a benchmark against which regulatory review of submissions made by the utilities can be conducted.

7.3.3 Upgradation of the In-house Code Severe Accident Analysis Program (SAAP)

The in-house developed Severe Accident Analysis program (SAAP) has been developed to study DEC conditions such as LOCA and failure of ECCS and station blackout in all Indian PHWRs. This code has been upgraded by undertaking the development of a fuel pin model that simulates thermal and mechanical behaviour of the PHWR fuel pin under accident conditions. The model incorporates one dimensional heat transfer equation in cylindrical coordinate system with constitutive relations for thermo-physical properties, fission gas generation and release, pellet-clad gap conductance, pin internal pressure, circumferential stress, and burst criteria, zircaloy oxidation and hydrogen generation. This model is used to develop a PHWR fuel bundle model by incorporating detailed convection and radiation heat transfer models. The models are benchmarked and incorporated into the basic structure of SAAP code as shown in Fig. 7.3.3.

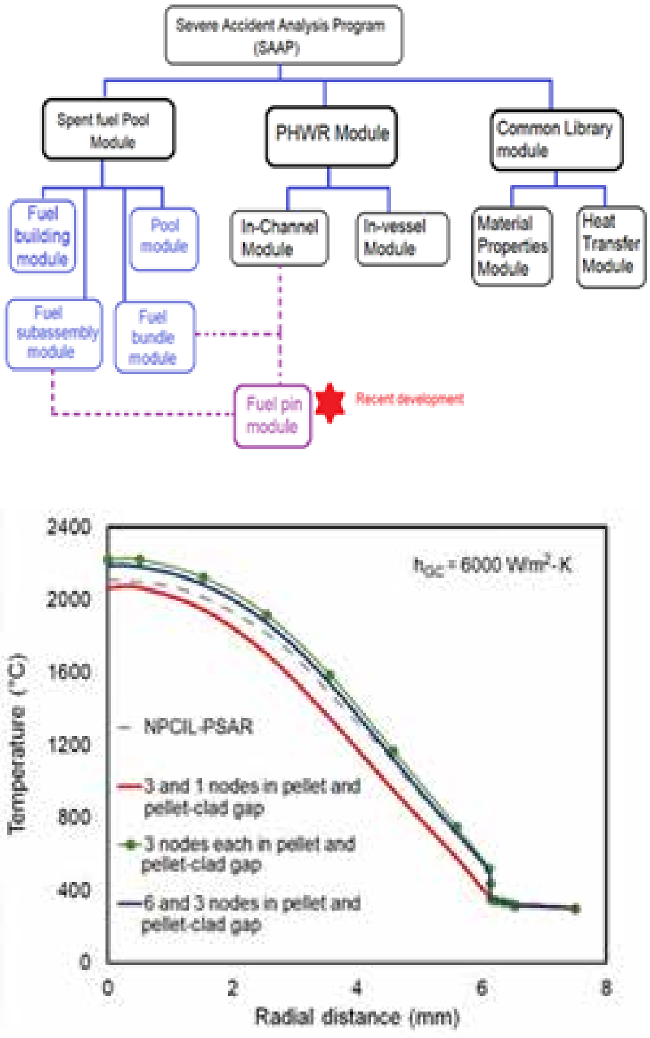


Fig. 7.3.3: Development of Fuel Pin Model within the SAAP Code and Benchmarking for Operating Parameters of PHWR

7.3.4 Studies on Transients of Coupled Natural Circulation Loops with Application to PDHRS

A generalized coupled loop two-phase computer code based on drift flux model is developed for application to passive reactor core cooling systems. It can simulate various orientations of heater-cooler in both loops. It employs water-steam property subroutine instead of the Boussinesq approximation. A key feature available in this code is its ability to capture flashing phenomena in the vertically oriented pipes. The code is validated against experimental data from several facilities such as CIRCUS-IV, PMCS and VISTA. A typical start-up flow transient in primary and secondary loop is depicted in Fig 7.3.4. The code can capture single-phase natural circulation stage (SNS), intermittent or transition stage (ITS) as well as the two-phase natural circulation stage (TNS). The influence of geometrical and operating parameters is also investigated and a sensitivity analysis has been carried out to identify dominant variables affecting the transients. This model can now be applied to study performance of PDHRS of PHWR-700 and passive moderator cooling system in AHWR.

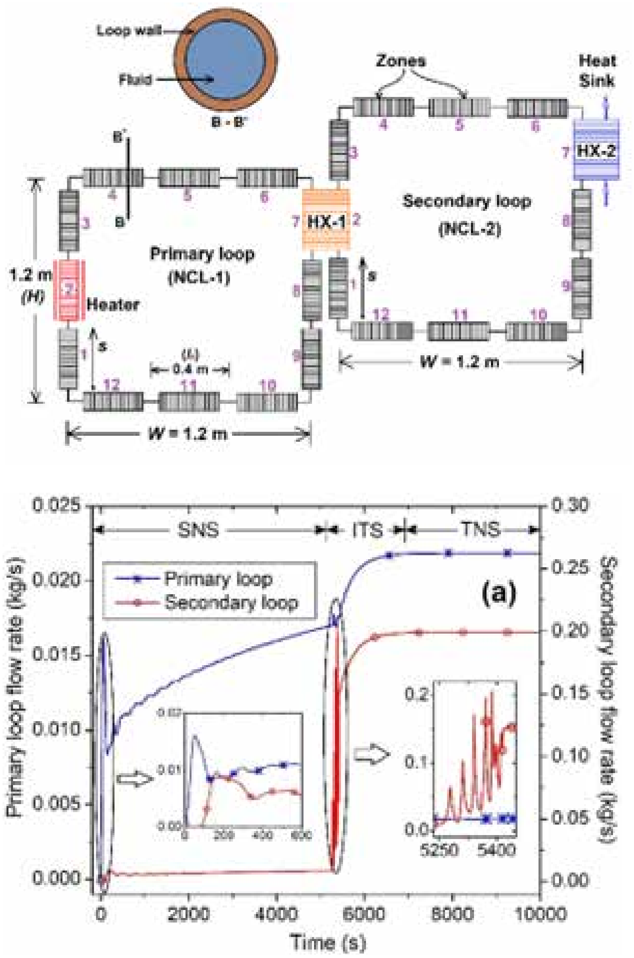


Fig. 7.3.4: Vertically Coupled NCLs and a Typical Flow Transient

7.3.5 Numerical Modelling of Fire Development in the Cable Spreader Room of an NPP

A mathematical model for cable fire development in a room containing several vertical vents (windows) is developed. The mass, energy and oxygen conservation equations are derived from basic principles and solved simultaneously to obtain fire parameters in the room. The model is benchmarked against Hinsdale Telephone Exchange (HTE), Illinois, USA fire data. It is then applied to study the consequence of cable fire in the cable spreader room of an NPP. The various processes occurring in the room during fire development such as; heat release rate, mass burning rate, pressure and temperature rise, breakage of window glass panes, inflow and out flow of air and hot gases, temperature profile across boundaries are captured. This model differs from earlier works by prescribing a criterion to arrive at a realistic, steady cable insulation-burning phase following the initial fast growth phase. The sudden opening of windows due to breakage of glass panes is also modelled. Fig. 7.3.5 shows the geometry of typical cable spreader room and cable burning transient.

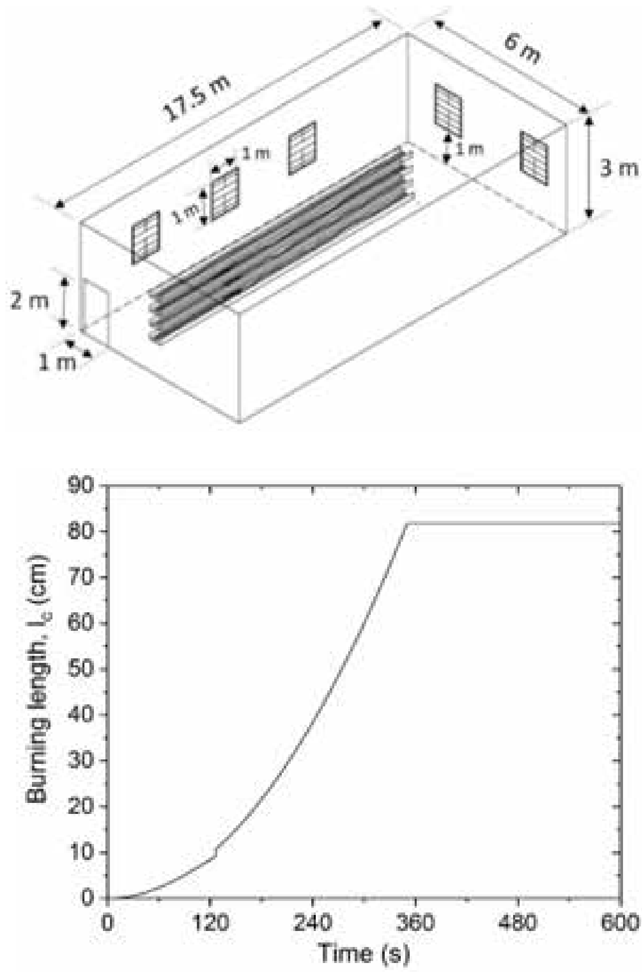


Fig. 7.3.5: Schematic of Cable Spreader Room and Cable Burning Transient

7.3.6 Contribution to PRABHAVINI Code Assessment

PRABHAVINI is an integral safety analysis code that is being developed by BARC along with other DAE units and AERB to analyze accident conditions in nuclear reactors. AERB is participating in development and validation of various modules of PRABHAVINI. As a part of PRABHAVINI Code assessment following activities were carried out:

a) Development of 700 MWe PHWR Containment Model in PRABHAVINI

Earlier, PARIRODHAN, a containment thermal hydraulic module of PRABHAVINI v3.0 was assessed against NUPEC M-4-3 hydrogen/helium distribution test. For subsequent use of PRABHAVINI for NPPs, development of 700 MWe PHWR containment model in PRABHAVINI was taken up. 700 MWe PHWR primary containment is modelled using several compartments. Opening between compartments are modelled using junctions while thermal inertia of containment walls and internal structures are modelled using SWALL (heat structures) components. The input deck was verified. To further gain confidence of correctness of 700 MWe PHWR containment input deck of PRABHAVINI, containment peak pressure (Fig. 7.3.6(a)) and temperature during LB-LOCA was estimated and compared with utility's predictions and found to be reasonably matching.

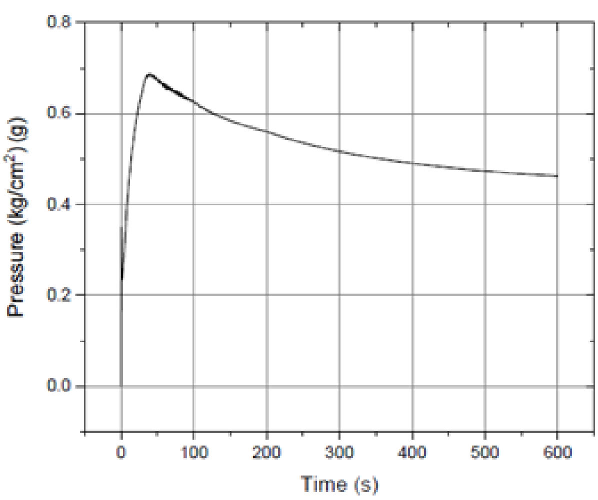


Fig. 7.3.6(a): Containment Pressure Predicted by PRABHAVINI

b) Assessment of PRAVAH and ABHA Module of PRABHAVINI

As part of an independent assessment and user feedback exercise for the PRABHAVINI code, an evaluation of the PRAVAH module (a computational model for simulating the heat transport system) and the ABHA module (a computational model for simulating the reactor core and its components) against the RELAP5 code has been conducted. One pass of 540 MWe PHWRs from Reactor Inlet Header (RIH) to Reactor Outlet Header (ROH) was modelled with one hot channel and one single average channel. Subsequently, a pseudo transient simulating a steady pressure change in the hot channel from an initial pressure of 11.4 MPa to 10.4 MPa followed by a return to 11.4 MPa was imposed. The resulting change in mass flow rate in the hot channel (Fig. 7.3.6(b)), change in total power (due to reactivity feedback) (Fig 7.3.6(c)), void fraction

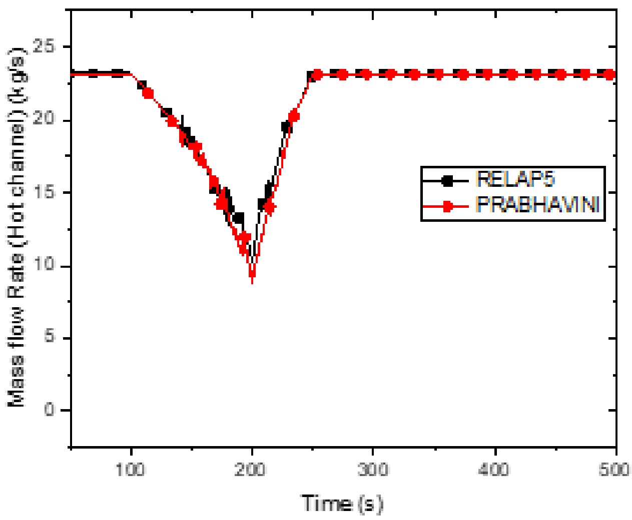


Fig. 7.3.6(b): Variation in Mass Flow Rate in Hot Channel

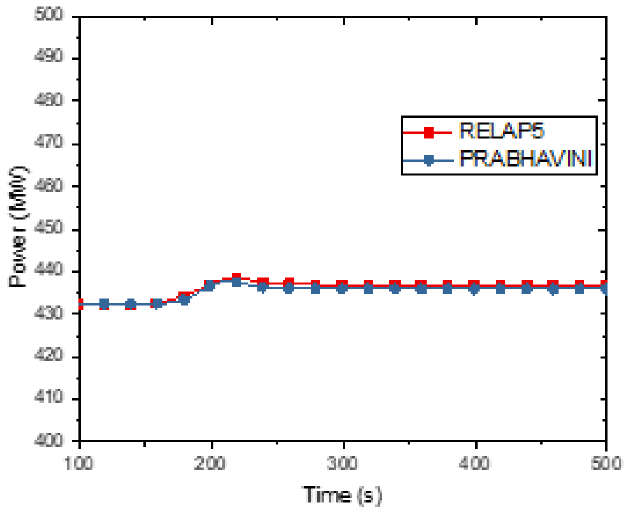


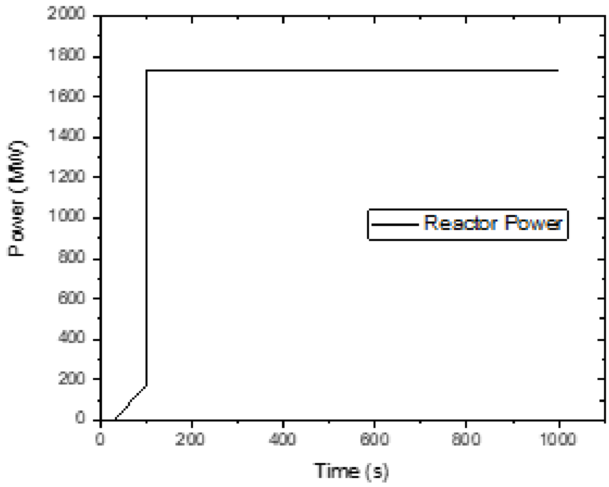
Fig. 7.3.6(c): Reactor Power

in both hot and average channel and core exit temperature was compared and found to be in good agreement.

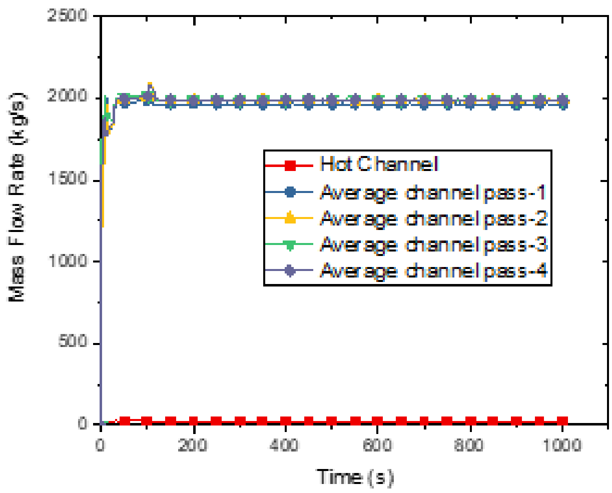
c) Steady State Analysis for 540 MWe PHWR using PRABHAVINI

As part of the ongoing assessment of the PRABHAVINI code and to provide user feedback to the developers, a steady-state analysis of a 540 MWe PHWR has been undertaken.

In the modelling process, the reactor channel was represented using the CPIPE component, with one pass simulated using two CPIPE components. One component represents the highest power channel, and the other represents average channel. The remaining three passes were modelled using three separate CPIPE components. Various core components, including Fuel, PT & CT, and associated radiation heat transfer, were also modelled using various RCOMP component of ABHA module. The simulation of reactor power was achieved using the NEUPOW component of the ABHA module. The secondary system modelling included the representation of the Steam Generator (SG) with feed water flow and steam flow as boundaries. Additionally, the Pressurizer, PHT pressure control logic, and SG level control were also included in the model. The steady-state values of crucial parameters, such as reactor power, header pressure & temperature, SG pressure and temperature, core exit temperature, and channel mass flow rate, were found to be within 1% of nominal values. The variations in reactor power and mass flow rate are illustrated in Fig. 7.3.6 (d) & (e), respectively.



(d) Reactor Power



(e) Variation in Mass Flow Rate in Hot Channel

Fig.7.3.6: Steady State Analysis of 540 MWe PHWRs

7.3.7 Coupled Thermal-Hydraulics Neutron Kinetics Benchmark Exercise

AERB participated in the Phase 1A (steady and transient neutronics) of benchmark exercise ABCS initiated by AERB using the in-house developed multi-point kinetics code MPKC. The MPKC code was developed primarily to couple neutronics with system thermal hydraulic code RELAP5. The Multi-point kinetics formulation is based on dividing the entire core into several regions and solving coupled ordinary differential equations (ODEs) describing kinetics in each region. The capability of this code was demonstrated by validating against the AECL 7236 benchmark problem describing a hypothetical LOCA arrested by SCRAM in a PHWR for large reactivity insertion rates. The MPKC code has been utilized to simulate ABCS Phase 1A benchmark problem. Effective multiplication factors (K_{eff}) for different core configurations, normalized azimuthal power distribution for steady state configuration, normalized total power and 3D peaking factor as desired by the benchmark have been estimated with SCRAM of 26 SORs for half-core voiding transients. The estimated results are in close agreement with the reference results of the benchmark. Salient results are provided in Fig. 7.3.7(a), 7.3.7(b), 7.3.7(c) and 7.3.7(d) respectively for steady state normalized power distribution, normalized power distribution during half core voiding transient and 3D peaking factor during half core voiding transient.

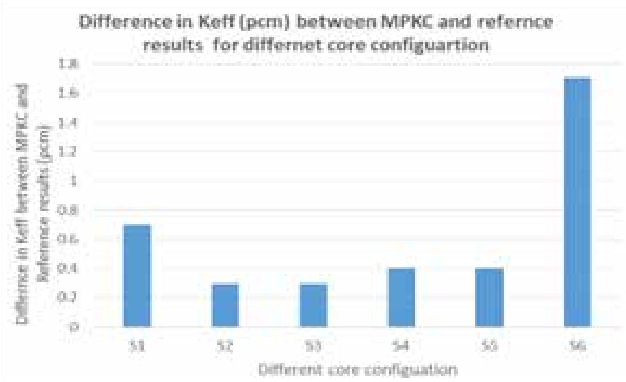


Fig. 7.3.7(a): K_{eff} Comparison for Different Cases

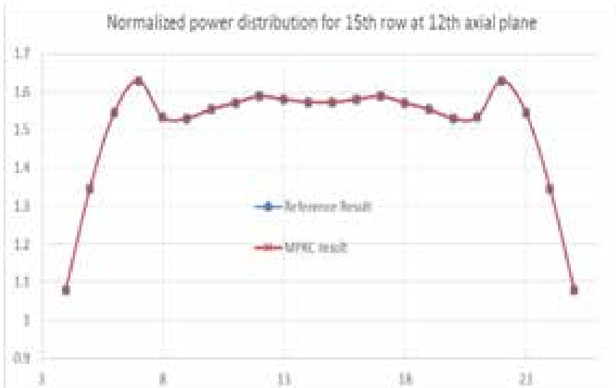


Fig. 7.3.7(b): Steady State Normalized Power Distribution Comparison

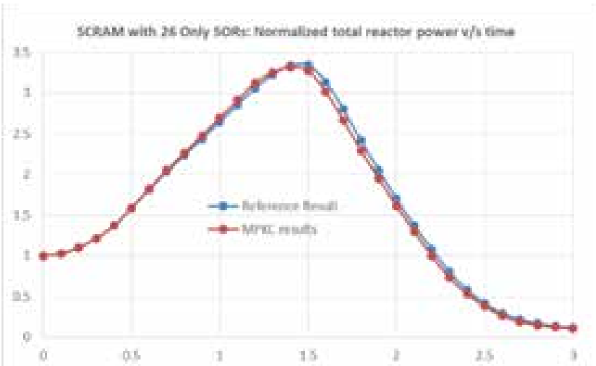


Fig. 7.3.7(c): Normalised Power Distribution Comparison during Half Core Voiding Transient

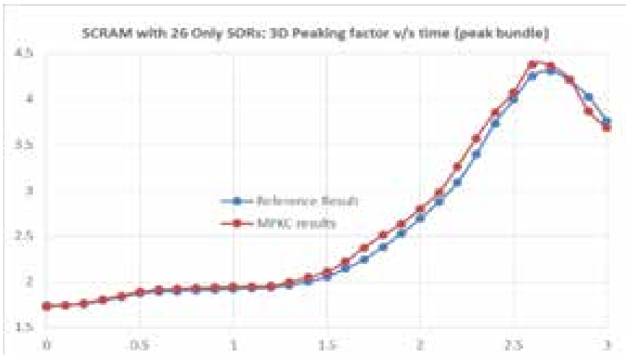
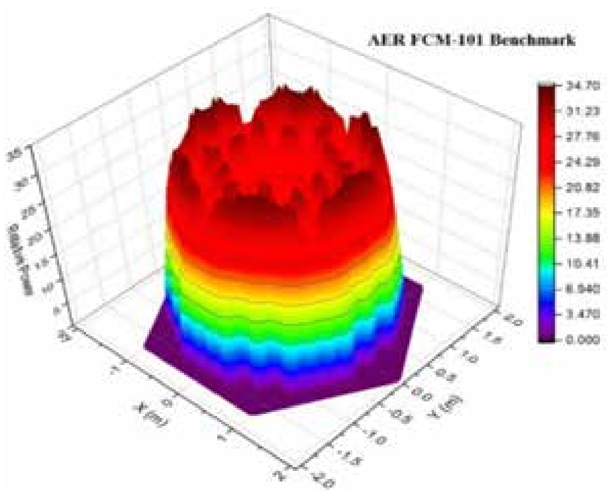


Fig. 7.3.7(d): 3D Peaking Factor Comparison during Half Core Voiding Transient

7.3.8 Development of Reactor Dynamics Code REDAC at AERB

Safety analysis of a nuclear reactor requires estimation of neutron flux, power distribution and associated core thermal state during normal operation and postulated events. A transient 3D reactor kinetics code REDAC (REactor Dynamics Analysis Code) has been developed at AERB for this purpose over the past few years. It solves 3D multi-group neutron diffusion equation, coupled with the fuel-coolant heat transport equations. REDAC offers flexibility in terms of reactor geometry, boundary conditions, spatial discretization and solution methods. Efficient numerical schemes have been employed for solving the governing equations. The performance of REDAC has been demonstrated by solving a few benchmark problems in different types of reactors. Some of these benchmarks include AECL-7236 (PHWR), AER FCM-101, AER DYN-001, AER DYN-002 (VVERs) and IAEA benchmark problems on PWRs. REDAC has also provided valuable inputs for safety analysis of Indian reactors. Some of the safety analyses performed using REDAC include estimation of critical channel powers for 700 MWe IPHWR, simulation of low power physics experiments in 1000 MWe VVER, simulation of power transients associated with LOCA and LORA in IPHWRs, etc. REDAC has a broad spectrum of applicability in terms of reactor geometry and the nature of the static/transient problems to be analysed. For illustration, Fig. 7.3.8 shows REDAC results for a couple of benchmark problems.



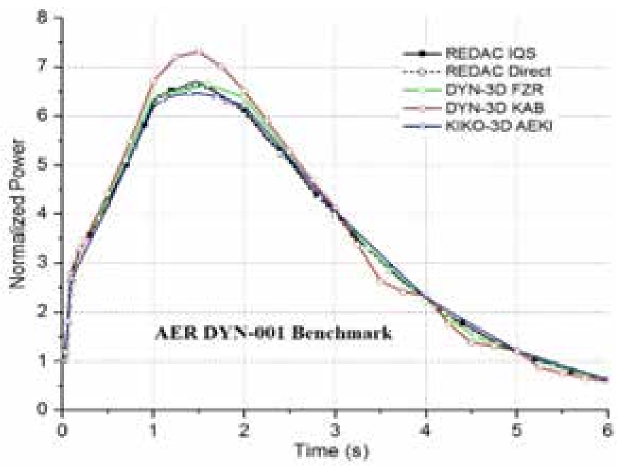


Fig. 7.3.8: Power Distribution (AER FCM-101 Benchmark) and Power History (AER DYN-001 Benchmark) Calculated using REDAC

7.4 Radiological Impact Assessment Studies

7.4.1 Determination of Source Term for Radioactive Releases by Inverse Modelling Technique

Assessment of the radionuclide source term and its composition is of vital importance in the event of any nuclear accident. Inverse modelling methods that combine environmental measurements with suitable atmospheric dispersion models are one of the effective methods for the estimation of the source term. In the present study, a variation approach that directly makes use of the gamma dose rate measurements for the source term estimation is used for a hypothetical release of radionuclides from Tarapur NPP site as a sample case. This modelling methodology is able to reconstruct the time evolution of the radionuclide species emitted for the fictitious release considered

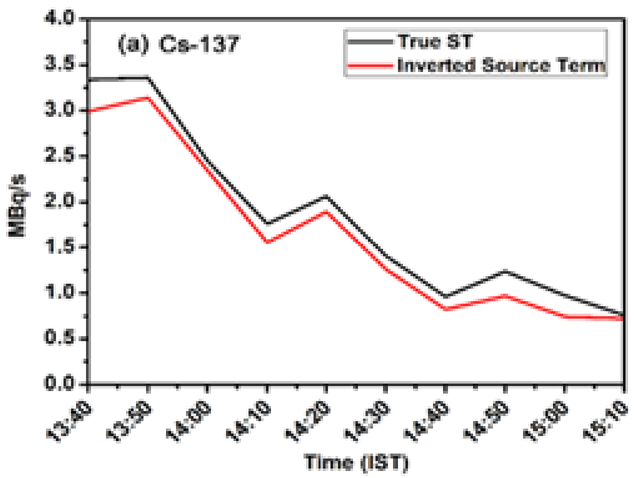


Fig. 7.4.1: Comparison of Inverted and True Source Term of ^{137}Cs

in the study. The study brought out that the estimated source term is in reasonably good agreement with the observed values in 90% of cases analysed. As a sample case, the comparison of the inverted and true source term of ^{137}Cs is shown in Fig. 7.4.1. The study also demonstrates the possible use of variational approach based inverse modelling technique in future Decision Support Systems for estimation of radioactive source term during nuclear emergencies.

7.5 Experimental Studies

7.5.1 Turbine Lube Oil Pool Fire Tests in Compartment Fire Test Facility (CFTF)

SRI-AERB has commissioned a Compartment Fire Test Facility (CFTF) for fire safety research in the area of pool & cable fires and its impact on safety. Confirmatory testing of burning behaviour of combustible fuels & solvents used in NPPs is undertaken in this facility. As part of this activity, a small setup was designed to test turbine lube oil used in PFBR to assess its fire hazard potential. Several pool fire tests were conducted to assess its burning behaviour. Since the lube oil is classified as a class-III liquid that is difficult to ignite, different ignition methods involving supply of electrical and thermal energy were employed to study its ignitability. Fig. 7.5.1 shows one experimental campaign in progress.

Fig 7.5.1: Pool Fire Experimental Facility for PFBR Turbine Oil

7.5.2 Influence of Catalyst Dosage on the Uptake of Uranium

The study was taken up to find out a solution for the uptake of uranium for very lean uranium sources like tailing ponds, rain water discharged from flooded uranium mines etc. As the technology adopted would find a solution for minimizing the uranium discharge to the environment, it would help in future regulatory decision making. As a

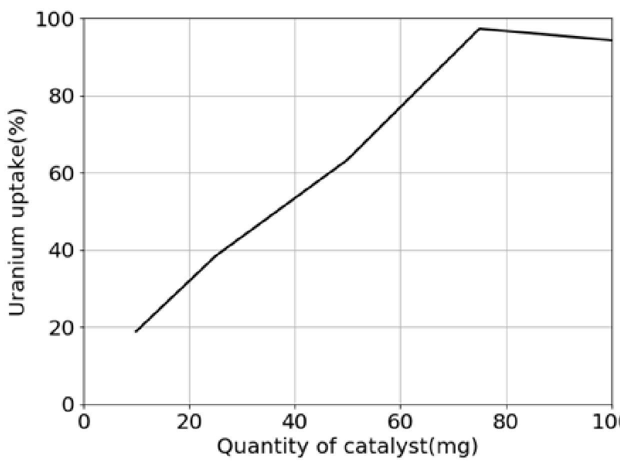


Fig.7.5.2: Influence of Catalyst Dosage on the Uptake of Uranium

part of the study, Graphene Oxide-Chitosan (CTS-GO) composite was synthesized in-house by cross linking chitosan and graphene oxide using modified Hummer's method.

The synthesized composite was characterized using XRD and SEM to assess its structure and morphology. Uranium adsorption studies indicate that more than 97% of uranium in uranyl nitrate solution could be removed at pH 4. The influence of pH towards the removal of uranium was found to follow the order acidic < neutral< alkaline indicating the electrostatic interaction between the catalyst and uranium at lower pH ranges although significant removal was observed in all the pH ranges. Results of this study shows that the synthesized chitosan-graphene oxide composite can effectively remove uranium from effluents arising from different process streams (Fig. 7.5.2).

7.5.3 Studies on Sorption of Iodine Species using Silver-doped Alumina

The study aims in keeping the iodine species in the aqueous phase itself without making it airborne thereby minimizing the release to the gaseous phase and hence to the environment. For reducing the volatile iodine inside reactor containment, it is essential to devise methodologies to retain iodine species in the sump without making it airborne, thereby limiting its potential transport out of the containment. Towards this study, silver

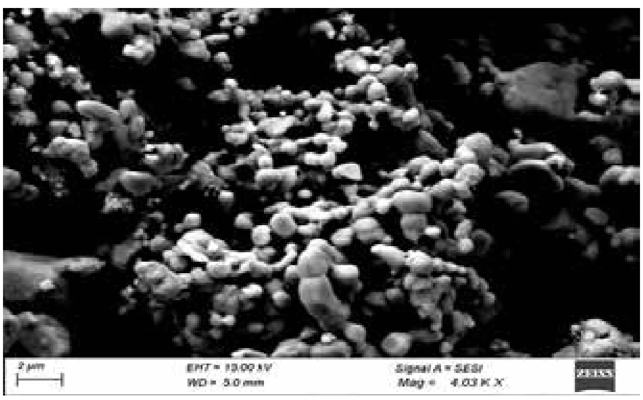


Fig.7.5.3(a): SEM Image of Silver Coated Alumina

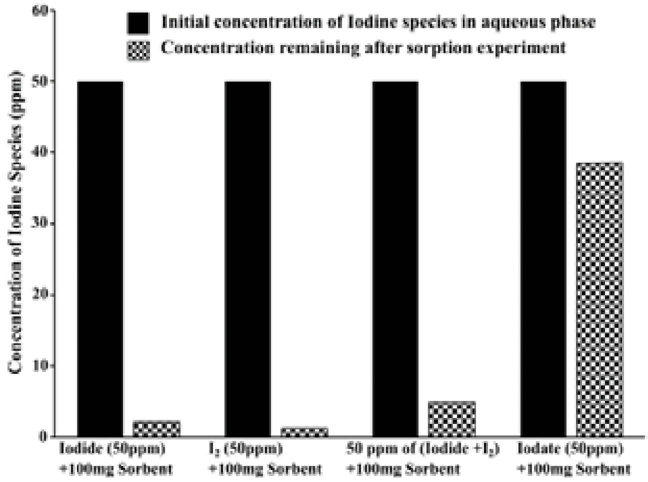


Fig.7.5.3(b): Sorption of Iodine Species using Silver-coated Alumina

coated alumina was synthesized in-house by chemical impregnation method (Fig. 7.5.3(a)). For the iodine sorption experiments, simulated sump solutions containing 50mg/L of iodine species were equilibrated with 100mg of catalyst for 2 hours and the extent of iodine retention was estimated using ion chromatographic method. More than 95% of iodine species and 23% of iodate could be retained by the catalyst (Fig. 7.5. 3(b)). The study demonstrates that the synthesized silver coated alumina catalyst is highly effective for the retention of iodine species, which could retain them in the aqueous phase itself.

7.5.4 Theoretical and Experimental Studies to investigate the Behaviour of Iodine inside Reactor Containment under Postulated Accidental Conditions

Theoretical studies were carried out using the FACTSAGE software based on chemical thermodynamics to predict the possible reaction products of iodine interaction with various species in the gaseous and aqueous phase. In parallel, experimental studies were carried out at the Chemistry laboratory of SRI using an iodine experimental set up to understand the influence of pH, temperature, organic impurities, iodinepaint interaction and irradiation effects on the iodine behaviour viz. transport and speciation. Both theoretical and experimental studies reveal that the rate of formation of methyl iodide formed upon iodine interaction with painted surfaces increases with temperature and with increase in concentration of organic impurities and thickness of painted surfaces. The formation of methyl iodide has been confirmed through measurement of Total Organic Carbon (TOC) as shown in Fig. 7.5.4.

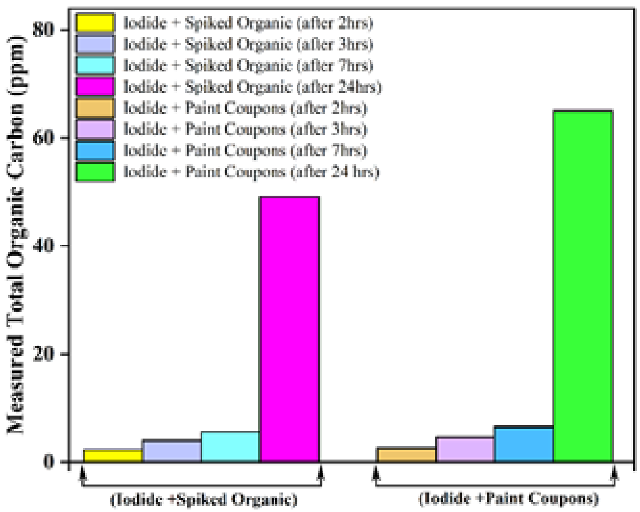


Fig.7.5.4: Measure TOC Values upon Interaction of Iodine with Painted Surfaces

The data generated through experiments would be very helpful in arriving at safety margins with regard to the iodine source term estimation, release inside the containment and planning the mitigation strategies to prevent iodine release to the environment.

7.5.5 Performance Evaluation of Alumina loaded Borophosphate Glasses for Waste Immobilization Applications

Borophosphate glasses have been explored as alternative matrices for waste immobilization applications owing to their superior characteristics over borosilicate counterparts. These glasses can be melted at lower temperatures thereby minimizing the volatilization of fission products during the vitrification process. Further, borophosphate glasses are known for their proven loading capacity for lanthanides and actinides, making them highly suitable for applications in waste immobilization. It is also observed that, addition of alumina to borophosphate glasses improves the overall structural and thermal properties of the matrices. In the present study, sodium calcium borophosphate glasses containing Al_2O_3 were synthesized using the conventional melt-quenching method. Structural characterization was performed using XRD, SEM-EDX and FTIR spectroscopic techniques to establish the suitability of the glasses. The analysis of the structural features indicated a uniform elemental distribution in the synthesized glasses. Studies on differential thermal analysis have demonstrated an enhancement in the thermal stability of borophosphate glasses, contributing to an increase in their chemical durability.

7.6 Reactor Physics Studies

7.6.1 Safety Assessment of Low Power Reactor Physics Experiments during 7th Fuel Cycle Operation of KKNPP-1

In the 7th fuel cycle of operation of KKNPP Unit-1, its fuel was partially switched from conventional UTVS to advanced TVS-2M type. To ensure that reactor physics parameters comply with the AERB safety criteria for such mixed core operation, independent verification calculations were carried out to support the safety review of the Low Power Physics Experiments at KKNPP Unit-1 during its Cycle-7 operation. These experiments were aimed to measure the temperature coefficient of reactivity, boric acid coefficient of reactivity, Emergency Protection (EP) worth, integral and differential worth of control groups of CPSARs etc. The measured values were compared with the theoretical estimations and found to be meeting the acceptance criteria.

7.6.2 Safety Review of the Proposal for Loading of RU/SEU Fuel Bundles in PHWR-220

It is envisaged to use Reprocessed Uranium (RU) in the currently operating 220 MWe PHWRs. The objective of using RU based fuel that could be slightly enriched uranium (SEU) is to enhance the average discharge burnup leading to reduced quantity of spent fuel generation during power operation. As a part of the safety review, verification of the reactor physics parameters was carried out by independent core physics analysis using DRAGON-DONJON code system, employing ENDF/B-VI.8 based cross-section data sets. The variation of neutron multiplication factors, isotopic composition changes with burnup, reactivity effects due to changes in moderator temperature, channel temperature, coolant temperature, fuel temperature, coolant void percentage, coolant/moderator purity, and boron/gadolinium poison concentration in the moderator etc. were calculated and found to be in good agreement with the design values.

7.6.3 Studies on the Neutronics Characteristics of VVER-1000 Reactor with Accident Tolerant Fuels

The neutronic characteristics of a VVER-1000 fuel assembly with Accident Tolerant Fuel (ATF), designed to endure severe accidents for a longer duration than the current UO_2/Zircaloy fuel were investigated. This work is taken up as an anticipatory R&D work. The analysis was carried out using the Monte Carlo based code, OpenMC with ENDF/B-VIII.0 based nuclear data. Both near-term concepts, such as, Cr-coated zircaloy claddings, Cr^{2O3}-doped UO_2 pellets, FeCrAl cladding and long-term concepts, such as, Uranium Nitride and Uranium Carbide (UC) fuel with SiC cladding, were considered for the analysis. Results of the study substituting ATF cladding for zircaloy, reveal a significant reactivity penalty for FeCrAl, a relatively smaller reactivity gain for SiC, and insignificant effects for Cr-coated cladding and Cr^{2O3}-doped pellets. Furthermore, for ATF fuels UN, UC, and Cr^{2O3} (1000 ppm) doped $UO_{2,}$ changes in reactivity and fuel isotopes were investigated and compared with conventional U^{O2} fuel. The variation of the infinite neutron multiplication factor ($K_{inf)}$ as a function of burnup is presented in Figs. 7.6.3(a) and 7.6.3(b) for various ATF cladding and fuel concepts, respectively.

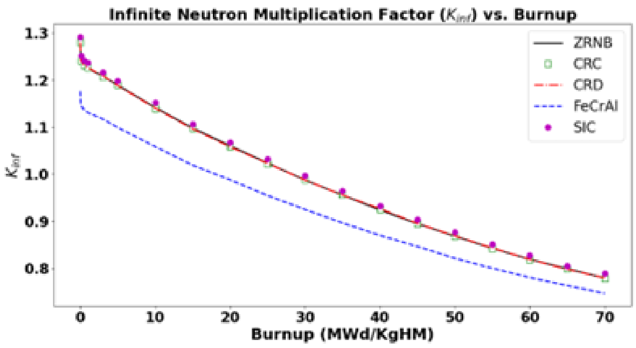


Fig.7.6.3(a): Variation of Neutron Multiplication Factor (K_{inf}) with Burnup

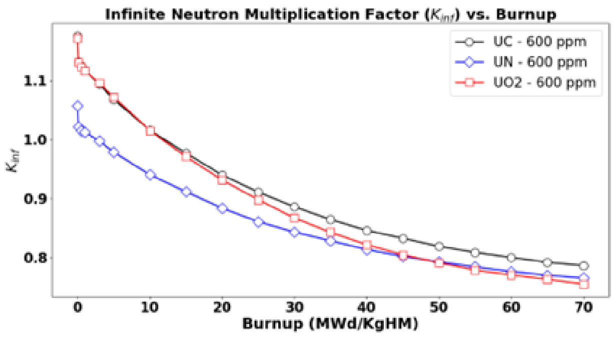


Fig.7.6.3(b): Variation of Neutron Multiplication Factor (K_{inf}) with Burnup

7.7 Structural Analysis and Material Studies

7.7.1 Development of Rolled joint model of Calandria tube in PHWR using ABAQUS

In PHWR, the calandria tube (CT) to calandria side tube sheet (CSTS) joint is a mechanical

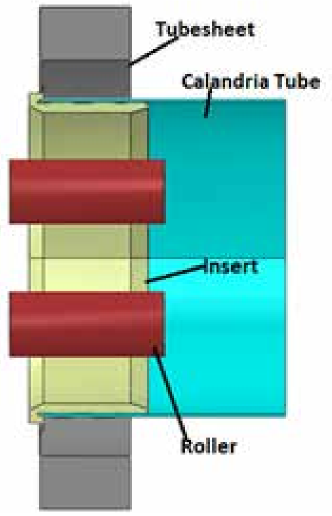


Fig. 7.7.1(a): Solid Model of the Rolled Joint Assembly.

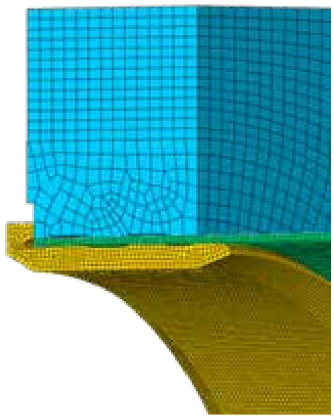


Fig. 7.7.1(b): Finite Element Discretization of the Rolled Joint Assembly

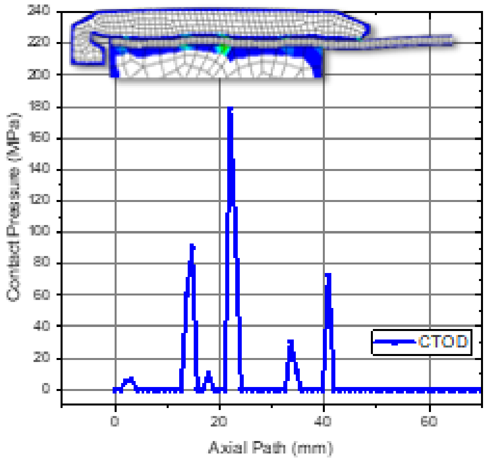


Fig. 7.7.1(c): Contact Pressure along Axis of Tube Developed at Calandria Tube Outer Surface

roller expansion joint. It is a special type of rolled joint called a sandwich rolled joint, wherein the calandria tube (Zircaloy-4) is sandwiched between the inner landed insert (made of SS 410 in full annealed condition) and the outer stainless steel tube sheet (SS 304L), as shown in Fig. 7.7.1(a). During the revision of safety guide on deterministic safety analysis of water cooled reactor based NPP (AERB/NPP-WCR/SG/D-19, Rev-1), acceptance criteria for calandria tube rolled joint temperature was deliberated. During anticipated operational occurrences (AOOs) and design basis accidents (DBAs), the temperature of CT-CSTS rolled joint will increase. It is important to maintain leak tightness and structural integrity of the rolled joint in these scenarios. Based on the deliberations in the meeting, assessment of the variation of contact pressure of the rolled joint with temperature is undertaken.

In the current work, the contact pressure after the formation of the joint at room temperature is evaluated. A 3D rolling simulation is carried out using ABAQUS as shown in Fig. 7.7.1(b). The analysis considers the motion of five rollers and the resulting plastic deformation. Finite element analysis shows that the contact pressure is not uniform along the axis of the rolled section and shows peaks at locations of local discontinuity due to grooves as shown in Fig. 7.7.1(c).

7.7.2 Structural Safety Assessment of Type C Package for Radioactive Material Transport

The safe transportation of relatively large amount of radioactive materials over long distances within short period will require Type C package. A type C package has to survive multiple stringent tests, the most notable being an impact test at a velocity not less than 90 m/s as per AERB Safety Code (AERB/NRF-TS/SC-1 (Rev.1)). The material must remain contained and shielded after the impact. Designing such packages is new, with limited tested concepts. A study has been initiated to explore energy absorption capabilities of such packages and proposes a new Type C package for a specific application.

In the present work, the dynamic deformation analysis of the PAT-2 package (Fig. 7.7.2(a)), designed by Sandia National Laboratory, USA is performed using ABAQUS/Explicit simulation. Weighing 33 kg and measuring 15 inches in diameter, the package was impacted at 90 m/s perpendicular to a rigid surface. The results

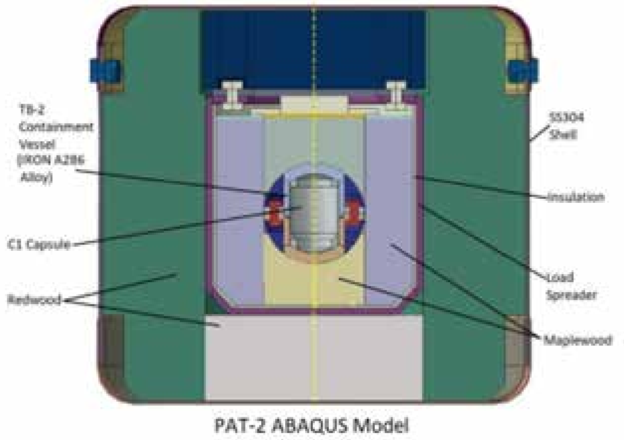


Fig. 7.7.2(a): PAT-2 Solid Model

indicate substantial deformation in both Redwood and Maplewood layers, while the inner containment vessel maintained integrity, securing radioactive materials (Fig. 7.7.2(b)). The study highlights the limitations of wood, specifically its impracticality for heavier packages due to low strength and large volume requirements.

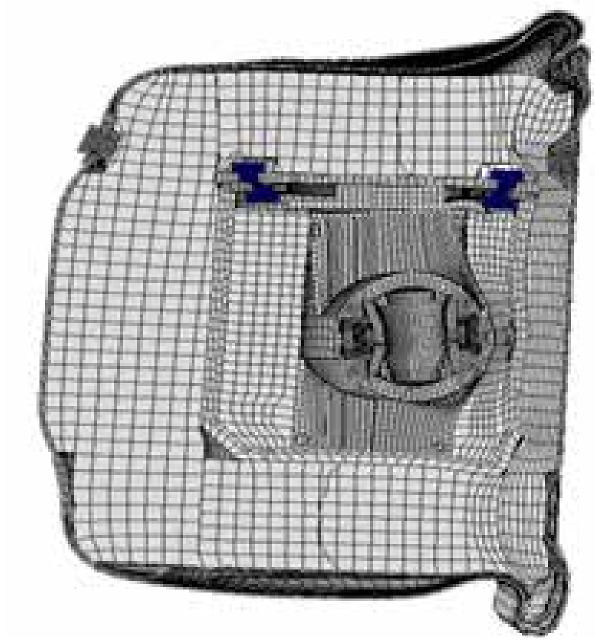


Fig. 7.7.2(b): Deformed Shape of PAT-2

Consequently, the usefulness of alternate energy absorbing materials, such as thin-walled metallic components, for heavier casks are being explored.

7.7.3 High Temperature Creep and Rupture Behaviour of Calandria Material SS 304L

Numerical studies associated with the structural integrity and retention capability of the calandria in the event of postulated severe accident scenarios in Pressurized Heavy Water Reactors (PHWRs) require high-temperature tensile and creep data of 304L SS. In this context, the behaviour of 304L stainless steel under high temperatures is analysed for creep deformation and rupture behaviour. Constant temperature and constant load uniaxial creep tests have been carried out at temperatures ranges from 973 K,1023 K and 1123 K, at selected stresses in the range of 250 MPa to 12.5 MPa.

It has been observed that both the secondary creep rate and rupture life follow a power-law dependence on the applied stress across all investigated temperatures (Fig. 7.7.3(a) and Fig. 7.7.3(b)). Particularly at 973 K, both the secondary creep rate and rupture life exhibited a two-slope

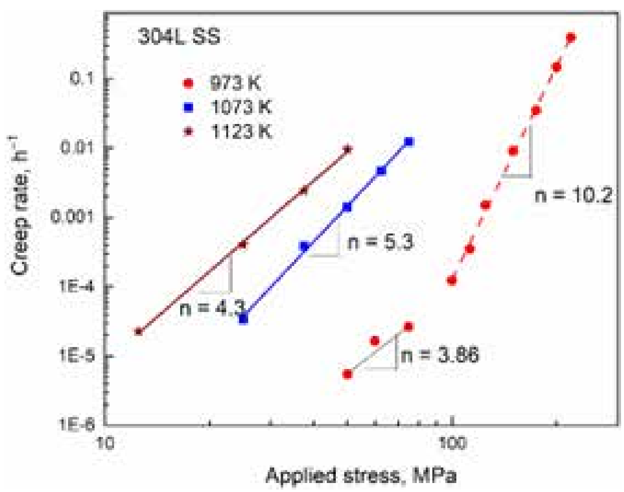


Fig. 7.7.3(a): Variation in Creep Rate versus Applied Stress

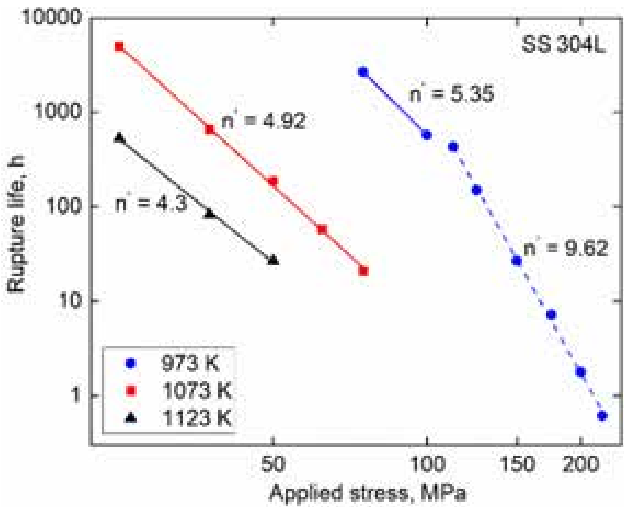


Fig. 7.7.3(b): Variation in Rupture Life versus Applied Stress

behaviour in relation to applied stress. The stress exponents associated with steady state (n) and rupture life (n) decrease with increase in temperature as well as with increase in applied stress. Further, a relation between applied stresses and Larson Miller parameter (LMP) was established, demonstrating the equivalence between rupture time and temperature. The Larson-Miller plot yielded a smooth master curve that facilitates prediction of stresses for any targeted exposure time and temperature within the investigated experimental domain. In addition to the above, creep rate evolution of 304L SS has been modelled by empirical models up to the onset of tertiary creep.

7.7.4 Deterministic Analysis of BWR Reactor Pressure Vessel using FAVOR Code

The Fracture Analysis of Vessels-Oak Ridge (FAVOR) computer program was developed by USNRC to perform deterministic and probabilistic risk-informed safety analyses of reactor pressure vessels (RPV) when subjected to a range of thermal hydraulic events. This code was used to perform deterministic safety assessment of the RPV of a typical BWR for flaws observed during in-service inspection (ISI). Different RPV load transients, like hydro test, normal start up and shutdown, upset, and emergency conditions were analysed. The results from thermo-mechanical analysis compared well with commercial FE software, ABAQUS. Typical hoop stress variation along RPV thickness is shown in Fig. 7.7.4(a) for the upset condition. Additionally, the stress intensity factors (SIF) for these flaws were also evaluated using FAVOR, which showed good agreement with SIF values obtained from in-house assessment

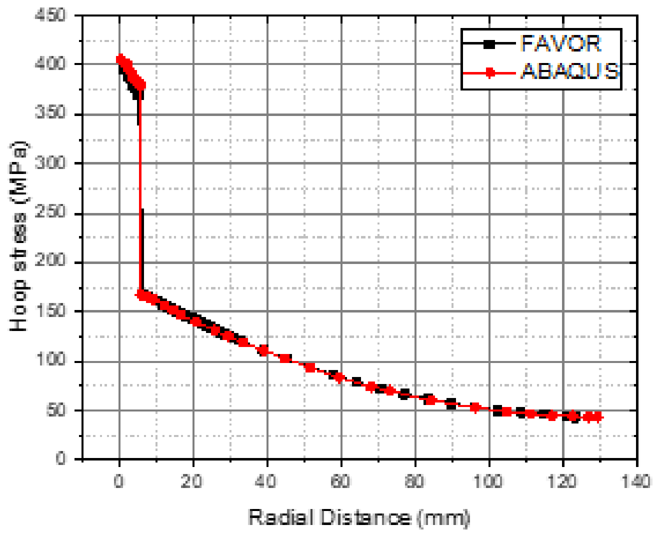


Fig. 7.7.4(a): Hoop Stress in RPV Wall

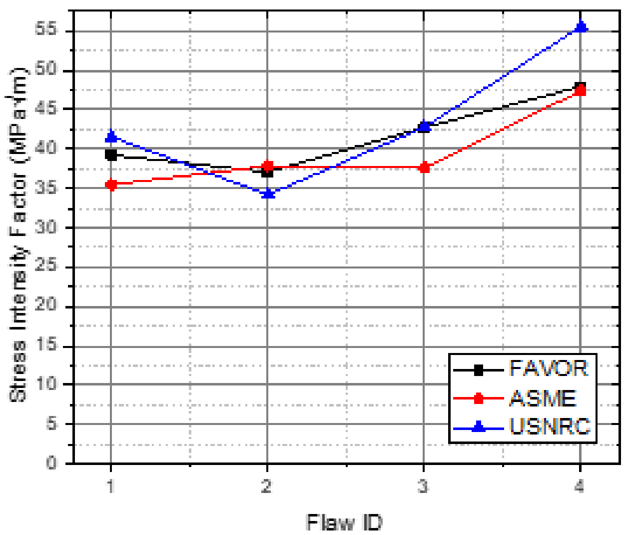


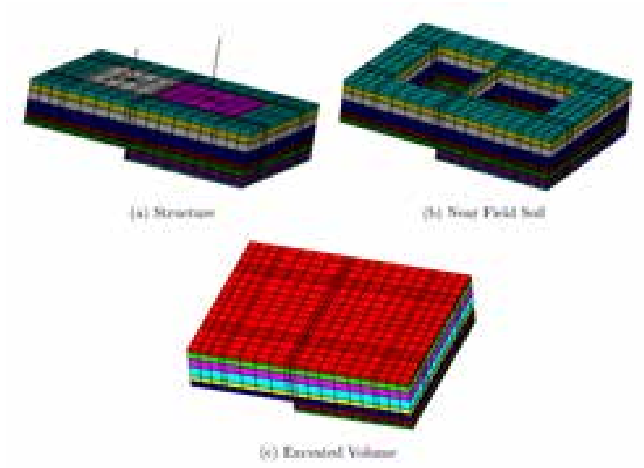
Fig. 7.7.4(b): SIF Values for Different Flaws

code based on ASME B&PV code and USNRC regulatory guide. The SIF values is illustrated in Fig. 7.7.4(b) for different surface flaws at the deepest point. Subsequently, FAVOR results were used for the deterministic safety assessment of RPV. Also, the benchmark problems with FAVOR is in progress to perform probabilistic safety assessment of RPV of LWRs.

7.8 Safety Studies to Support Review and Assessment

7.8.1 Study on Efficacy of Frequency Domain SSI Techniques for Deeply Embedded Structures

Seismic soil-structure interaction (Seismic SSI) plays a crucial role in structures that have large, deep foundations and embedment. Nuclear industry has largely relied on frequency domain approach as implemented SASSI software for Seismic SSI of safety related structures. Given the significance of Seismic SSI, a Standard Problem Exercise (SPE) was formulated in collaboration with the US NRC to evaluate the effectiveness of the frequency domain soil structural interaction method in analysing deeply embedded structures. The exercise involving simulation of responses of reactor turbine building configuration of NUPEC test was carried out for recorded ground motions in ACS SASSI software. The study reveals that the SSI methodology utilizing LB, BE, and UB soil characteristics effectively captures certain aspects of the dynamic behaviour of deeply embedded structures. However, some differences were observed in the frequency response spectra at high frequencies and induced pressure at deeper soil strata as shown in Fig. 7.8.1



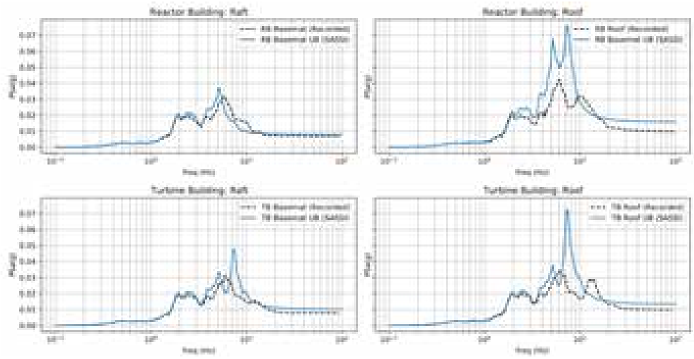


Fig. 7.8.1: Frequency Response Spectra at High Frequencies and Induced Pressure at Deeper Soil Strata

7.8.2 Safety Assessment of Primary Containment of 700MWe (KAPP-3&4) for Internal Pressure

During the review of analysis and design of containment structures, certain issues pertaining to analytical design model, such as eccentricity of unsymmetrical buttresses, unequal length of horizontal pre-stressing cable etc, were identified. It was decided to undertake a study on structural response of containment structure considering

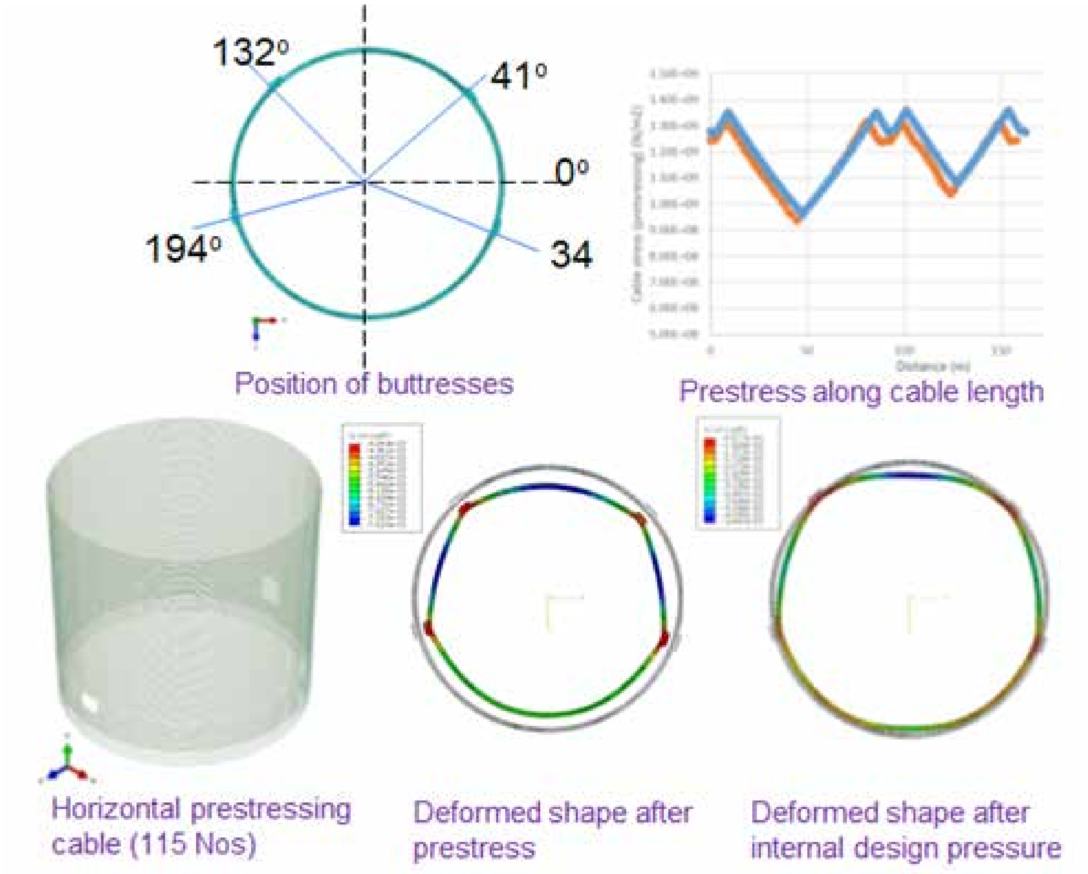


Fig. 7.8.2: Details of the Model and Results of Analysis

all aforesaid attributes. The study was divided into two phases; phase-1: structural response up to design limit and phase-2: structural response beyond design limit leading to ultimate load capacity (ULC).

Phase-1 of the study, where finite element model of containment structure is analyzed for internal pressure load up to design limit, was undertaken. The FE model considers detailed geometric features including individual pre-stressing cables considering elastic material properties. The analysis considered variation in pre-stress force along the length of the cable. Based on the analysis, deformations in IC wall as well as the dome are estimated immediately after pre-stress, after gravity and after application of pressure and compared with the undeformed state of the containment.

The deformation at the locations of buttress are seen to be lower compared to the deformations in the other areas due to eccentricity of the buttress from the IC centre line. The net deformation in West axis of IC wall at El 110m due to pressure loads is lower as compared to the East axis due to effect of additional stiffness near the MAL openings (Refer Fig.-7.8.2).

The study demonstrated the importance of modelling the pre-stressing buttress in the geometrical model and the variation of pre-stress along the length of cable to obtain the realistic responses of the containment structure.

7.9 AERB Funded Safety Research Programme

AERB promotes and funds research in radiation safety and industrial safety as part of its programme. AERB Committee for Safety Research Programmes (CSRP) frames guidelines for the same and also evaluates, recommends grants for research projects and monitor their progress periodically. During this period, CSRP approved renewal/extension of seven ongoing projects. The details are given in Table 7.1.

AERB also provides financial assistance to Universities, Research Institutions and Professional Associations for holding symposia and conferences on the subjects of interest to AERB. During this period, AERB had received about 28 applications requesting financial assistance for conducting Seminars, Symposium and Conferences.

Table 7.1: Research Projects Renewed/Extended

S. No.	Project Title	Principal Investigator	Organisation
1	Low Pressure Nanofiltration for Removal of Monovalent and Bivalent Salts from Leached Liquor during Alkaline Uranium Ore Processing	Prof. Sirshendu De	IIT, Kharagpur
2	Numerical Crack Growth Studies in Hydrided Pressure Tube of PHWR	Prof. Indra Veer Singh	IIT, Roorkee
3	Phytoremediation of Radioactive Elements (Cesium and Strontium) from Contaminated Soil and Water	Dr. N.K. Dhal	CSIR- IMMT Bhubaneswar
4	Experimental and Numerical Evaluation of Double Containment Structures of Indian PHWR against Hard Missile Impact due to External Event	Dr. Mohd. Ashraf Iqbal	IIT, Roorkee
5	Molten Corium Concrete Interaction Studies	Dr. Arunkumar Sridharan	IIT Bombay, Mumbai
6	Study of Fundamental Heat Transfer Characteristics in the Presence of Non-Condensable for Designing Long Term Passive Heat Removal System for Containment	Dr. Arunkumar Sridharan	IIT Bombay, Mumbai
7	Development of an On-Line Measurement System for Hydrogen Concentration in Steam Environment	Dr. U. Ramachandraiah	Hindustan Institute of Technology and Science, Chennai.

CHAPTER -08

ENGAGEMENT WITH STAKEHOLDERS AND PUBLIC OUTREACH

ENGAGEMENT WITH STAKEHOLDERS AND PUBLIC OUTREACH

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 conducts various programmes and maintains its website with all relevant and updated information; issues press releases on matters related to nuclear and radiation safety, publishes quarterly e-newsletters and annual report. The details of above activities carried out during the year are given below.

8.0 AERB and Media

AERB issues press releases / website updates to keep the public informed about its important activities. The press releases are issued in Hindi and English. Details of the press releases are available on AERB website. AERB reviews news items related to nuclear and radiation safety published in various newspaper & the web and provides its response if required. AERB also routinely responds to queries obtained through AERB website.

8.1 Communication and Consultation with Stakeholders

AERB provides all necessary information to its stakeholders through its website, annual reports, newsletters, press releases/briefings and media interviews. Stakeholders and public are informed on issues related to radiological safety, major regulatory decisions, special technical reports etc. through AERB website. Information on operating NPPs including validity of operating licence, RIs, significant events, radioactive effluent discharges, occupational exposures etc. are also provided on AERB's website. AERB publishes quarterly e-Newsletters in English and Hindi which are uploaded on its website.

8.2 Strengthening of Regulatory Interfaces

8.2.1 DPIIT, Ministry of Commerce & Industry

AERB interacted with Department for Promotion of Industry and Internal Trade (DPIIT) towards Integration of e-LORA system with National Single Window System (NSWS).

8.2.2 Ministry of Health and Family Welfare

AERB officials participated as a member of Interim Commission constituted for regulation and maintenance of standards of education and services for Allied Healthcare Professionals and other related matters.

8.2.3 Department of Atomic Energy (DAE)

AERB continued to interact with DAE for administrative support in governance related matters and in matters for strengthening inter-ministerial interfaces such as integration of AERB licenses in NSWS of DPIIT, inter-governmental coordination mechanism for regulation of import of radioactive material and radiation generating equipment. AERB also provided its views and advice from radiological safety standpoint on matters specifically referred such as exercising control over atomic minerals and prescribed substances, disposal of exhausted resin generated after treatment of water etc. AERB also interacts and supports DAE in matters related to processing of representation, grievances and appeals as well as legal matters, which are directly or indirectly related to AERB's mandate.

8.3 National Conference on Regulatory Interface -2023

Atomic Energy Regulatory Board (AERB) has been conducting thematic National Conference on Regulatory Interface (NCRI) every year since 2017. The objective of the NCRI is to provide a platform to exchange views and opinion with the Licensees of AERB.

This year, AERB hosted a one-day NCRI-2023 on December 08, 2023 at Mumbai. The theme was "Safety Regulations in Mining, Milling and Fuel Fabrication Facilities". Around 50 participants from various units attended the conference in person and several participants attended the conference through online mode. Feedback on AERB's regulatory processes were obtained from participants of NFC, UCIL and IREL. The queries of the participants were addressed in a panel discussion, held at the end of the conference.

Shri D.K. Shukla, Chairman AERB addressing NCRI-2023

Dignitaries at Panel Discussion during NCRI-2023

Delegates attending NCRI-2023

8.4 Public Awareness Activities

8.4.1 AERB participated in 108th Indian Science Congress (ISC) – Pride of India (PoI) expo held in, Nagpur, Maharashtra in the first week of January, 2023. AERB had setup an exhibition stall to display various exhibits on its regulatory framework and functions as a part of public awareness activities.

A large number of students, teachers, healthcare/ environment professionals including general public visited AERB exhibition stall and interacted with the AERB officials.

AERB Officials interacting with Students during Exhibition in 108th Indian Science Congress

8.4.2 AERB set up an informative exhibition stall in DAE-BRNS biennial symposium on "Nuclear and Radiochemistry-2023" (NUCAR-2023), in the first week of May 2023, at the Department of Atomic Energy (DAE) Convention Centre in Anushaktinagar, Mumbai. The exhibition stall at the symposium provided details of regulatory requirements in the use of radiation sources, especially sources used in research and regulatory requirements in the nuclear fuel cycle facilities. Students/faculty members from various universities and representatives of industries actively interacted with AERB officials.

Exhibition Stall in DAE-BRNS Biennial Symposium on "Nuclear and Radiochemistry-2023" (NUCAR-2023)

8.4.3 Public Awareness in the Vicinity of NPPs

AERB conducted awareness programs in the vicinity of NPPs to engage with public and inform them in brief about AERB, its mandate, the facilities & activities it regulates, and its functions. Following events were conducted near NPPs:

8.4.3.1 Awareness Event near Kakrapara Site

An awareness program was conducted at C. N. Kothari Homeopathic Medical College and Research Centre, Vyara, Gujarat on July 13, 2023. The programme was attended by faculty members and students of the institute.

8.4.3.2 Awareness Event near GHAVP Site

On the eve of Teacher's day,an awareness program was conducted for school teachers and principals of various schools located in the vicinity of GHAVP, Haryana. The gathering interacted actively with the AERB officials and queries of the participants were adressed satisfactorily by AERB officials.

8.4.3.3 Awareness Event near Rajasthan Site

An awareness program was conducted for around 300 school children and teachers in various schools (3 nos) located in the vicinity of Rajasthan site, on October 11, 2023. Following the program, AERB officials interacted and clarified the queries raised by the participants.

Public Awareness Event at Rajasthan Site

8.5 Development of Short Awareness Film

A bilingual film on AERB was developed for showcasing it in public awareness programmes. The film was released on Independence day (i.e. August 15, 2023) by Chairman, AERB. The film covers in brief information about inception of AERB, its mission, the facilities & activities it regulates, its functions & decision making process and its strengths to perform regulatory functions.

8.6 Awareness Programmes for Stakeholders for Radiation Facilities

8.6.1 Awareness Program for Manufacturer/ Suppliers of Scanning Equipment

In India various X-ray based equipment are used for scanning & analytical purpose, which includes X-ray baggage inspection systems, Food Scanners, PCB analysers, XRF etc. These scanning equipment are manufactured in India as well as imported from other countries. An online awareness program was conducted on January 27, 2023, by AERB to strengthen the role of manufacturer/suppliers in ensuring radiation safety.

8.6.2 Awareness Program on Radiological Protection in Therapy with Radiopharmaceuticals

An awareness program on "Radiological Protection in Therapy with Radiopharmaceuticals" was conducted on February 9, 2023 on virtual mode. The program was attended by participants from various licensed Nuclear Medicine facilities. The participants were able to gain valuable insights on the regulatory framework in Nuclear Medicine therapy, update on patient release criteria in ^{177}Lu therapy and the requirement of delay-tank, and special safety considerations for Alpha Therapy.

8.6.3 Awareness Program on Regulation in Research Accelerators

An awareness program on "Regulation in Research accelerators" was conducted on February 22, 2023 in virtual mode. The program was attended by participants from various research facilities such as RRCAT, VECC, IPR, IUP AC, etc.

8.6.4 Awareness Program on Safe Management of Disused Sources

A safety promotional meet on "Safe management of disused sources" for Nucleonic Gauge (NG) users / suppliers, was conducted on December 12, 2023 at AERB, Mumbai to disseminate information on regulatory requirements and role & responsibilities of NG users / suppliers with regard to safe management of disused NG sources. The program was attended by participants from NG Suppliers and end-user of NGs possessing disused sources.

8.6.5 Awareness Program on Safety & Regulatory Aspects in Industrial Radiography

State-wise webinars/seminars were conducted for the Licensee and Radiological Safety Officers

(RSO) of Industrial Radiography Facilities on Radiation Safety & Regulatory Inspections of Industrial Radiography (IR) practice with an objective to improve awareness on radiation safety in industrial radiography facilities and thereby to enhance safety culture of such facilities. Topics related to Radiation Protection and Regulatory Aspects of IR Facilities, Regulatory Inspection of IR practice, Accidents in IR practice & Lessons Learned, and User Guidance on AERB e-Licensing web portal (e-LORA) for IR practice were covered during the programme.

Eastern Region Regulatory Centre (ERRC) conducted the programme (Webinar) for the States of Assam, Bihar, Odisha & Jharkhand. 30 participants attended the programme.

Southern Region Regulatory Centre (SRRC) conducted the programme in hybrid mode for the State of Tamil Nadu with physical participation of facilities in and around Chennai in SRRC auditorium, and virtual participation of facilities outside Chennai in Tamil Nadu. A total of 47 participants attended the programme at SRRC and about 30 participants attended virtually.

AERB HQ along with Northern Region Regulatory Centre (NRRC) conducted the programme (Webinar) for the States of Madhya Pradesh, Punjab, Goa, Gujarat, Uttarakhand, & Rajasthan. about 61 participants attended the programme.

Participants actively interacted with AERB officials during the programme and sought clarifications on safety and regulatory aspects of industrial radiography practice and processing of licensing applications.

8.7 DAE Safety & Occupational Health Professional Meet

AERB and Uranium Corporation of Indian Ltd. (UCIL) jointly organized the 39th DAE Safety and Occupational Health Professional Meet during December 27-29, 2023 at Narwapahar Site. The themes for this years Meet were 'Proactive efforts to maintain safety culture & role of technology in enhancement of safety' and 'Ergonomics and stress management'.

Chairman, AERB delivered Dr. S. S. Ramaswamy Memorial Endowment lecture on the "Developing, Sustaining and Strengthening of Safety Culture" during the meet. Distinguished speakers from the field of industrial safety and occupational health delivered talks which proved to be of immense value to the audience. About 100 participants attended the event. The meet provided a platform for information sharing by the practising professionals to further enhance the safety culture & stress management. An exhibition showcasing

Shri Dinesh Kumar Shukla Lighting the Lamp

Shri Dinesh Kumar Shukla delivering Dr. S. S. Ramaswamy Memorial Endowment Lecture occupational & fire safety related equipment manufactured by various private industries was also arranged during the meet.

AERB presents Industrial Safety awards and Fire Safety Awards every year to the DAE units which achieves highest performances in Industrial Safety. During the meet, AERB Industrial Safety Awards and Fire Safety Awards for the year 2022 were presented to the winners of DAE units.

Industrial Safety awards

The Industrial Safety awards are given based on the relevant inputs/data received from each unit and its assessment with the set parameters that include longest accident-free period, implementation of safety management system, injury statistics, dangerous occurrence, type of plant and operation, safety training imparted to personnel and efforts made by the plant towards improving safety. For Industrial Safety award, DAE units are categorized based on nature of plant operation as Production Units-I and II, R&D and other Low Risk Units, and Construction Units category. Winners of the AERB Industrial Safety Awards - 2022 in various categories are as follows:

Table 8.1: List of Winners for Industrial Safety Award for the Year-2022

Categories / Groups	Winners
Construction Units	Rajasthan Atomic Power Project – 7&8
Production Units –I (NPPs & HWBFs)	Kaiga Generating Station – 3&4
Production Units –II (Others)	Zirconium Complex, Pazhayakayal
R & D and other Low Risk Units	Heavy Water Board Facility - Vadodara

Winner AERB Industrial Safety Award 2022 (Production Units-I): Kaiga Generating Station – 3&4

Winner AERB Industrial Safety Award 2022 (Production Units-II): Zirconium Complex, Pazhayakayal

Winner AERB Industrial Safety Award 2022 (R&D and Other Low Risk Units): HWBF-Vadodara

Fire Safety Awards

The Fire safety awards were instituted by AERB to ensure that maximum efforts are made by the DAE units to prevent occurrences of fire incident and ensure that appropriate management system is in place to prevent fire in these units. The award is based on the marks obtained through review and assessment of input/data on management system, efforts for improvement, training and fire incident statistics. DAE units are categorized as Category-I and Category-II units based on fire potential. Following units were the winners of the AERB Fire Safety Awards – 2022 in these categories.

Table 8.2: List of Winners for Fire Safety Award for the Year -2022

Categories / Groups	Winners
Category –I (high fire risk units)	Kaiga Generating Station – 3&4
Category-II (low fire risk units)	Kakrapar Atomic Power Project – 3&4

Winner AERB Fire Safety Award 2022 (Category I) - KGS - 3&4

Winner AERB Fire Safety Award 2022 (Category II) - KAPP - 3&4

8.8 Theme Meeting for Stakeholders

8.8.1 Theme Meeting on "Classification of Radioactive Waste"

A Theme Meeting to share experiences on the application of AERB Safety Guide on "Classification of Radioactive Waste" was organized on March 6, 2023. About 100 officials from various organizations viz. NPCIL-HQ, NPPs, AERB, IGCAR, UCIL, BRIT and BARC, participated in the meeting. Shri D. K. Shukla, Chairman, AERB, in his inaugural address emphasized the importance of an effective and harmonized radioactive waste classification scheme, considering both national practices and IAEA safety standards for application of graded approach in radioactive waste management. Dr. C.P. Kaushik, Former AD, NRG, BARC delivered the keynote address on "Innovation & Challenges in Radioactive Waste Management". Invited speakers delivered talks on various topics related to radioactive waste classification and its application.

Glimpses of Theme Meeting

8.8.2 Theme Meeting on Regulatory Control of Radioactive Discharges to the Environment and Disposal of Solid Waste

A Theme Meeting on "Regulatory Control of Radioactive Discharges to the Environment and Disposal of Solid Waste" for radiation facilities was organized on February 17, 2023. Around 40 participants from Nuclear Medicine Facilities and Board of Radiation Isotope and Technology (BRIT) attended the theme meeting.

Glimpses of Theme Meeting

8.8.3 Theme Meeting on Nuclear and Radiological Emergency Preparedness & Response

A Theme Meeting on "Nuclear and Radiological Emergency Preparedness & Response: Strengthening based on Feedback from Stakeholders" was organized on February 24, 2023. Around 100 officials from various organizations viz. NPCIL-HQ, NPPs, CMG-DAE, BARC, NDMA and AERB participated in the meeting. Shri D.K. Shukla, Chairman, AERB, in his inaugural address, highlighted AERB's initiatives in the recent past to achieve a paradigm shift in approach for emergency response especially the early phase and the necessary arrangements to ensure a required level of preparedness. The key note address was given by Dr. A. K. Nayak, Head, NCPW and Chairman, CMG-DAE. The technical sessions were followed by a panel discussion chaired by Former Chairman, AERB, Shri S.A. Bhardwaj.


Glimpses of Theme Meeting

8.9 Webinars for Stakeholders

8.9.1 Webinar on AERB Regulatory Document

A seminar was organized to disseminate the information covered in the revised publication on AERB Safety Standard on 'Civil engineering Structures important to safety of Nuclear Facilities (AERB/NF/SS/CSE Rev-1), on September 12, 2023. The program was conducted in hybrid mode with more than 75 participants from BARC, NPCIL, DCSEM, NRB, HWB, NFC and IGCAR.


Participants attending the Webinar

8.9.2 Webinar on Experiences during NPP Project Phase

AERB is organizing Webinar-cum-Lecture Series for sharing "Experience during NPP Project Phase". These webinars / lectures will share the experiences gained during the projects' construction, commissioning stages by the regulatory body and the utility. This year, AERB organized 5 webinar sessions on various topics.

CHAPTER -09

PUBLIC ACCOUNTABILITY

PUBLIC ACCOUNTABILITY

Openness and transparency in dealing with the public and other interested parties is essential to promote confidence and trust in the actions and decisions of AERB. AERB as a government organization is under statutory obligation to comply with the provisions of the Right To Information Act, 2005. AERB, as a national regulator, is also committed to redress public grievances and giving responses to Parliamentary Questions in a transparent and time bound manner. The details of activities carried out during the year are as follows.

9.0 Grievance Redressal

AERB responds to the grievances received through Centralised Public Grievance Redress and Monitoring System (CPGRAMS). For this purpose, AERB has designated a Public Grievance Officer with contact details available on website. Total

16 grievances were received through CPGARMS portal and 9 grievances/complaints were received through posts/emails. All grievances were duly responded.

9.1 Right to Information Act

The 'Right to Information Act' (RTI) of Govt. of India which came into force on October 12, 2005 has been implemented at AERB. Under this Act, access to information from a public agency is a statutory right of every citizen. For dealing with the RTI, AERB has designated Central Public

Information Officer (CPIO), Assistant Public Information Officer (APIO) and Transparency Officer with contact details available on website. The management of AERB is committed to disclose all relevant information in public domain as is permissible under the Act. Required measures were taken on the implementation of RTI and the required information have been put on AERB website. The frequently asked questions (FAQs) under RTI were compiled and uploaded on AERB website for information of the public.

AERB replied to 138 RTI queries during the year 2023. Year wise RTI queries replied by AERB during the last five years are given in Figure 9.1

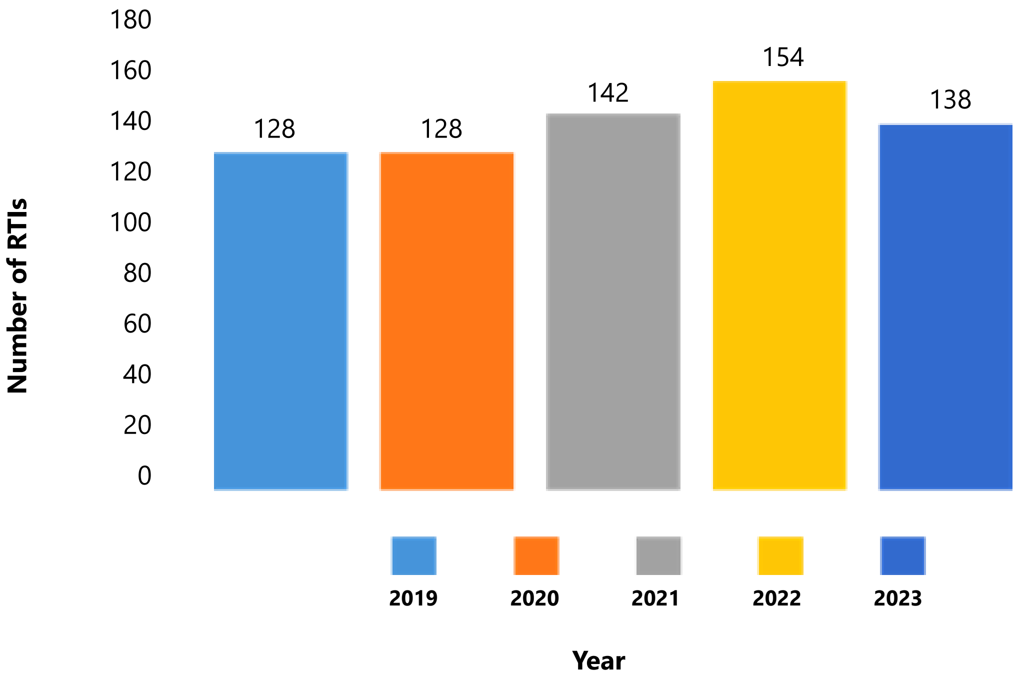
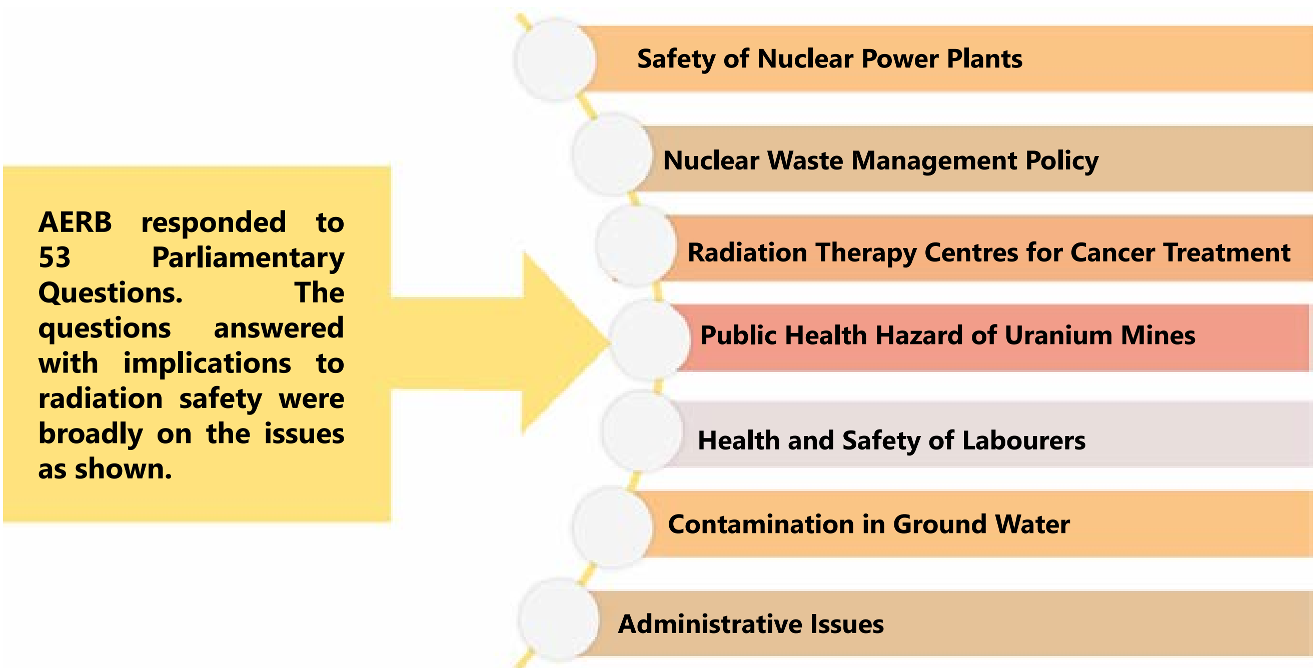


Figure 9.1: RTI queries replied during last 5 years

9.2 Parliamentary Questions

During the year 2023, AERB submitted responses to 53 parliamentary questions related to regulation of NRFs. The questions answered with implications to radiation safety were broadly classified under seven issues as given below:



CHAPTER -10

INTERNATIONAL CO-OPERATION

INTERNATIONAL CO-OPERATION

India is signatory to several international conventions related to nuclear safety and security such as Convention on Nuclear Safety (CNS), Convention on Physical Protection of Nuclear Material and its amendment 2005, Convention on Assistance in the case of Nuclear Damage and Radiological Emergency, Convention on Early Notification of a Nuclear Accident etc. India is also committed to implement the provisions of International Atomic Energy Agency (IAEA) Code of Conduct on 'Safety of Research Reactors' and Code of Conduct on the 'Safety and Security of Radioactive Sources'. AERB is obliged to fulfil the responsibilities assigned to it under these instruments. AERB actively participates and contributes in several multi-lateral international activities organized by IAEA and Nuclear Energy Agency (NEA).

AERB has bilateral co-operation arrangements with the regulatory bodies of France, Russia, Ukraine, United States of America, Finland, Canada, Bangladesh, United Kingdom, Vietnam, Uzbekistan and Slovak Republic. Some of the important activities carried out under the multilateral and bilateral international arrangement during the year are as follows:

10.0 Strengthening Nuclear Safety and Security

10.0.1 Joint 8th and 9th Review Meeting of the Convention of Nuclear Safety

The Government of India ratified the Convention on Nuclear Safety (CNS) on March 31, 2005. The objective of this Convention is to achieve and maintain a high level of nuclear safety worldwide and to establish and maintain effective defenses in nuclear installations against potential radiological hazards. CNS review Meetings are held every three years and provides opportunity to review the National Reports of all Contracting Parties.

Indian Delegates at Joint 8th & 9th Review Meeting of CNS

Indian delegation led by Chairman AERB, with experts from AERB, Bhabha Atomic Research Centre (BARC), Nuclear Power Corporation of India Limited (NPCIL) and the India's Permanent Mission in Vienna, participated in Joint 8th and 9th Review Meeting (RM) of the Convention on Nuclear Safety (CNS) at IAEA, Vienna, Austria, during March 20-31, 2023.

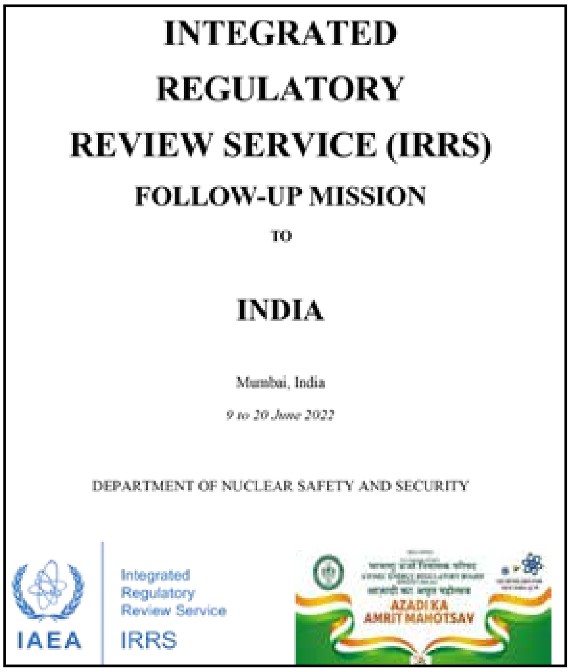
The presentation and peer review of the National Report of India was held on March 21, 2023. The

Shri Dinesh Kumar Shukla, Chairman, AERB addressing during CNS Meeting

presentation of India highlighted noteworthy practices in India's nuclear programme, response to challenges and suggestions identified in the previous RMs and areas of good performance in India's safety & regulatory framework. India was commended for seven areas of good performance. No challenges were identified for India in the Joint 8th and 9th RM of CNS. Members of Indian delegation also attended the plenary sessions, Open Ended Working Group (OEWG) discussions and presentations of other countries. The review process of CNS provides a forum to gauge the safety practices and regulations in India with respect to the international benchmarks and best practices. The experience of Joint 8th and 9th RM of CNS indicates that India's safety and regulatory practices are at par with the international benchmarks and best practices. Shri S B Chafle, Executive Director, AERB chaired the country group-5 review meetings during CNS.

10.0.2 Report of IRRS Follow-Up Mission made Public

The Integrated Regulatory Review Service (IRRS) of International Atomic Energy Agency (IAEA) follow-up mission to India with extended scope was conducted during June 9-20, 2022. The final IRRS report is made public and is now available on AERB website (https://www.aerb.gov.in/storage/uploads/News/newscBUFs.pdf)


INTEGRATED REGULATORY REVIEW SERVICE (IRRS)

FOLLOW-UP MISSION

TO

INDIA

Mumbai, India

9 to 20 June 2022

DEPARTMENT OF NUCLEAR SAFETY AND SECURITY

IAEA | Integrated Regulatory Review Service IRRS | AZADI KA AMRIT MAHOTSAV

10.1 Bilateral Co-operation

10.1.1 Bilateral Arrangement with Slovak Republic

AERB signed a MoU with Nuclear Regulatory Authority of the Slovak Republic (UJDSR) on

Shri Dinesh Kumar Shukla, Chairman, AERB signing MoU with Nuclear Regulatory Authority of the Slovak Republic (UJD-SR)

September 25, 2023 for the exchange of technical information and co-operation in the field of regulation of safe use of nuclear energy for peaceful purposes. The MoU will remain in effect for a period of five years.

10.1.2 Bilateral Meeting with United States Nuclear Regulatory Commission

A bilateral meeting was held with United States Nuclear Regulatory Commission (USNRC) at AERB, Mumbai during February 13-15, 2023. The meeting was arranged in hybrid mode. Some of the important issues discussed during the meeting were emergency preparedness and response, new reactor technologies, industrial radiography practice, regulatory control during transport of radioactive material and management of disused sealed sources.

AERB Officials with USNRC Delegates

10.1.3 Participation in Workshop on 'Long Term Operation Reviews'

AERB delegation participated in a workshop on 'Long Term Operation Reviews' hosted by USNRC during July 24-28, 2023. The workshop was also attended by delegates of France, Japan, Republic of Korea and Spain. Some of the important topics discussed during the workshop were Ageing Management Review, Ageing Management Program and Time Limited Ageing Analysis.

10.1.4 Meeting with ASN

AERB has a bilateral co-operation arrangement with ASN, the Nuclear Safety Authority of France. A Bilateral meeting between AERB and ASN was held in virtual mode on January 13, 2023 focusing on enhancing the bilateral relations. The probable areas for future collaboration were discussed during the meeting.

10.1.5 Visit of Bangladesh Delegation to AERB

A delegation from Bangladesh visited Atomic Energy Regulatory Board (AERB) on November 21, 2023 and held discussion with AERB officials as part of the 4th Joint Committee Meeting between India and Bangladesh. During the discussion both the parties affirmed to carry forward the technical co-operation between AERB and Bangladesh Atomic Energy Regulatory Authority (BAERA) under the bilateral arrangement. The delegates also visited Nuclear and Radiological Emergency Monitoring Centre (NREMC) at AERB.

AERB Officials interacting with Delegates from Bangladesh at NREMC

10.1.6 IAEA General Conference

Chairman, AERB, as part of Indian delegation, attended the 67th IAEA General Conference held during September 25 - 29, 2023 at Vienna, Austria. He also attended the Senior Safety and Security Regulator's meet and side-line meetings with delegation from regulatory bodies of Slovak Republic, VietNam and Argentina arranged during the General Conference.

Glimpses of IAEA General Conference

10.1.7 Visit of Director General, IAEA

IAEA Director General, Rafael Mariano Grossi along with his delegates visited India from 23-26 October, 2023. This visit marked Mr. Grossi's first trip to India as the Director General of the IAEA. During the visit, the delegates visited the Department of Atomic Energy (DAE) and met Chairman, Atomic Energy Commission and Secretary DAE, Dr. Ajit Kumar Mohanty, Chairman, AERB, Mr Dinesh Kumar Shukla along with other senior officials of the DAE.

Glimpses of the Visit of Director General, IAEA

CHAPTER -11

HUMAN RESOURCES DEVELOPMENT AND INFRASTRUCTURE

HUMAN RESOURCES DEVELOPMENT AND INFRASTRUCTURE

Human resource in AERB 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 carried out through induction of Graduate Trainees from Orientation Course for Engineering Graduates and Science Post Graduates (OCES) of DAE units and induction of postgraduates through AERB Graduate Fellowship Scheme (AGFS) from IITs, direct recruitment, lateral transfer of experienced personnel from operating plants and R&D institutes of DAE and transfer from non-DAE units.

The human resources and their management, development and infrastructure are further described in this chapter.

11.0 Enhancing Organisation Excellence

The allocation of responsibilities and authorities to different levels in the organisation for discharge of the functions is contained in Integrated Management System (IMS) adopted by AERB. While, this provides the required accountability in the system, for achieving excellence in work environment, it is also crucial to have the 'Right person for the Right Job'. Recognising that AERB's greatest asset are its employee and workplace excellence of an organisation is directly proportional to the extent the organization engages with its employees, AERB conducted two opinion surveys within the organisation with participation of all its employees. For unbiased and fair opinions, the surveys were kept anonymous.

11.0.1 Right Person For The Right Job

The first survey was an attempt to elicit views/ opinion of employees of AERB on eligibility cum selection criteria for choosing the 'right person' for heading a Division/Directorate in AERB. About 80% of scientific and technical staff participated in the survey. 97% of the participants responded in affirmative on the need to have criteria for the post of Head of Division in AERB. The factors considered for deciding eligibility criteria (to have a panel) were overall grade seniority and technical competency. Employee were asked to provide weightage for these on a scale of 1 to 5 (5 being highest). Opinion were sought to provide weightage for these factors. The factors for deciding selection criteria for the candidates in the zone of consideration were knowledge and understanding of management & regulatory processes, leadership qualities (interpersonal skills),ability to mentor and assess the subordinates, ability to formulate the long-term strategies, ability to prioritize and organize the work plan and knowledge about administrative aspects.

11.0.2 Organisation Climate

With regard to the second survey, the guiding factor was to have an overall assessment of workplace climate for which workplace satisfaction is a key element. Opinion were sought to provide weightage for these factors. Individuals in key positions can positively influence the work environment. How employees feel about the organisation is in direct co-relation to the quality of the superiors whom they report. For this purpose, an employee opinion survey was designed to elicit feedback on the attributes the employee thinks are important towards assessment of their superiors, namely the immediate superior, Section Head and Division Head. Eleven leadership attributes were identified for the survey such as leading by example, trustworthiness, accessibility, mentoring abilities, etc. About 75- 80% of the participants were mostly satisfied with immediate superiors, Section Heads and Division Heads.

Results of both the survey were shared with the employees and presented to the Board and are being formalised in IMS for implementation.

11.1 Human Resource

The total sanctioned strength of AERB is 459, and the manpower strength as of December 31, 2023, is 361. This year, 10 officials joined, while 17 officials retired/transferred/ resigned from AERB. The manpower is being augmented through induction of Graduate Trainees from Orientation Course for Engineering Graduates and Science Post Graduates (OCES) of DAE units and direct recruitment mode.

11.2 Employment of Persons with Disabilities

Persons with Disabilities (equal opportunities, protection of rights and full participation) Act, 1995 and implementation of reservation policy for Scheduled Castes / Scheduled Tribes / Other Backward Class (OBC) is implemented in AERB. Rosters are maintained as per the orders on the subject. The backlog vacancies are worked out and periodic reports and returns are sent to DAE.

11.3 Integrated Management System

AERB has developed and implemented Integrated Management System (IMS), in line with IAEA Safety Standards titled Leadership and Management for Safety (No. GSR Part -2, 2016).The documents are categorised as Level-1, 2&3. While Level-1 is the topmost document which contains the delegation of decision making authority and the policy statements, Level-2 provides the strategies and strategic directions to implement the policy and the process descriptions including the interfaces while Level-3 is the lowest set of documents containing the work plans, checklists, procedures, etc.

Currently, IMS Level-1 document is being revised to align it with the provisions of IAEA's GSG 12 document with a view to bring in better clarity and to give necessary flexibility to cater to anticipated circumstances and demands.

As IMS concerns all the employees in AERB, the revision of the document is being taken up in an inclusive manner with participation of all. A dedicated web space in AERB's intranet portal was created for obtaining comments. The revision work of IMS level document is in progress.

11.4 Training

As part of competence development, AERB continues to train its staff by organizing orientation training courses, On-the-Job Training (OJT) at nuclear and radiation facilities, periodic refresher training courses, workshops, seminars/ webinars, technical talks, colloquia and participation in national and international programmes. AERB also provides internship training to the students of various academic institutes.

11.4.1 Orientation Training Programme for New Recruits

Orientation Training for 16 newly joined Scientific & Technical Staff was conducted during May 22 to June 29, 2023. The training consisted of physical and recorded video lectures.

11.4.2 On-the-Job Training (OJT)

In year 2023, On-the-Job Training was continued for 10 AERB officials at NPP sites viz. RAPS & KAPS to get hands-on experience.

11.4.3 Internships

AERB provided internships to more than 35 students from academic institutes during this year.

11.5 Training on Communication at IIMC, Delhi

A training program on Communication was arranged for AERB officials at Indian Institute of Mass Communication (IIMC), New Delhi in July 2023. Fourteen AERB officials participated in the training programme. The training programme covered topics like Media Landscape in the Country, Social Media Ecosystem, Crisis Communication, Conducting a Press Conference and Elements of Press Release.

AERB Participation at IIMC, New Delhi

11.6 Knowledge Management

11.6.1 AERB Colloquium / Technical Talk

AERB conducts technical talks/colloquia for its staff for knowledge up-gradation. The topics are chosen in line with the mandate and functioning of AERB, covering latest scientific and technical development worldwide in the field of nuclear and radiation industries, regulatory practices and aspects enhancing personal and interpersonal effectiveness etc.

The talks/colloquia were organized on the following topics

i. Management of Radioactive Waste generated at Fukushima Site
ii. Radiation Protection aspects during Decontamination & Decommissioning of Nuclear Facilities
iii. Management of Radioactive Waste generated at Fukushima Site
iv. Fundamentals of Nuclear Security and Regulations pertaining to Security of Nuclear and Radiation Facilities
v. Leave Travel Concession and Travelling Allowance
vi. Children Education Allowance & Hostel Subsidy
vii. Challenges in Construction Industry
viii. Robots in Industry and Healthcare
ix. Inner Cleansing and Redesigning Self

11.6.2 Management Development Programme (MDP)

A five day Residential Training on 'Management Development Programme (MDP)' was arranged at Yashwantrao Chavan Academy of Development Administration (YASHADA), Pune in August, 2023. Twenty nine AERB officials attended the programme.

MDP at YASHADA, Pune

11.6.3 Knowledge Management Portal

A dedicated Knowledge Management System (KMS) have been set up to disseminate the available knowledge base and further augment knowledge base to meet the challenges of the future.The 'Knowledge Management System' is functional on the internal website of AERB, as part of knowledge preservation and easy retrieval of information. Training/ Refresher course/Teaching material, proceedings of Conferences and Seminars, etc. were uploaded on the portal at regular intervals. AERB regulatory documents viz. Codes/Standards/Guides/Manuals have also been uploaded on the portal.

11.6.4 Scientific Information Cell

A well-equipped scientific information cell (Library) has been maintained at AERB. 31 publications were uploaded in Knowledge Management System (KMS). 27 new books were added to the library. The total collection of publications in library is 10,721. In addition, 7 Journals and 1 Database were subscribed during the period. World Nuclear News, IAEA Weekly News, NEA News Bulletin etc., are circulated in digital form regularly through e-mails to AERB staff.

11.6.5 Promotion of Excellence in Human Resources

The following officers have successfully completed their PhD with Homi Bhabha National Institute(HBNI):

- Shri Arun Aravind, SO/F completed PhD on "Observational and Numerical Modelling Studies of Atmospheric Flow and Dispersion of Air-borne Releases over Kaiga Complex Terrain Site".
- Shri Ramakrishna Pagoti, SO/F completed PhD on "Luminescence Properties of Lanthanide and Actinide Doped Borophosphate Glasses".

11.7 Seminar on "Role of Nuclear Energy in the Decarbonising World"

As a part of Azadi Ka Amrit Mahotsav (AKAM) celebrations, a seminar on "Role of Nuclear Energy in the Decarbonising World" was conducted on January 24, 2023. Shri S.A. Bhardwaj, former Chairman, AERB and Dr. R.B Grover, Emeritus Professor, HBNI and Member, Atomic Energy Commission were the distinguished speakers for the seminar. Shri Bhardwaj spoke on the emerging nuclear technologies while Dr. Grover highlighted

Shri S.A. Bhardwaj, Former Chairman, AERB delivering Talk during Seminar the role of nuclear energy in the country's energy mix. Around 150 delegates participated in the seminar.

Dr. Grover delivering Talk during Seminar

Dignitaries and Participants attending the Seminar

11.8 Infrastructure Development

11.8.1 New Office Building

The construction of new office building has been completed and process of obtaining occupancy certificate through local authorities is in progress. As a part of green energy initiative, AERB had installed 25 kWH solar power roof top panels in its complex, which generated a total of 33,098 units this year.

New Office Building - Niyamak Bhavan- C

11.8.2 Construction of SRI Engineering Hall (Phase-II)

Engineering Hall-II is being setup to augment the existing experimental infrastructure at SRI. It is envisaged that around six new experimental facilities can be built within Hall-II. This infrastructure will cater to the long-term in-house

Engineering Hall-II

R&D programs of AERB to address regulatory safety issues and performance assessment of FOAK systems.

11.8.3 Setting up of PCCS Facility

Passive Containment Cooling Systems (PCCS) are being extensively used in the new generation reactors to mitigate the consequences of severe accidents. The regulatory review of such FOAK passive safety systems where the driving forces are minimal, poses a challenge. In view of the above, it is planned to set up a versatile PCCS facility in the SRI engineering hall. The objective of this facility is to investigate the performance of two-phase, parallel channel natural circulation PCCS loops under low thermal driving force. The design of the facility has been completed. The fabrication of the facility components has commenced and nearing completion. Figure shows a schematic of the proposed setup.

Schematic of the Experimental Setup

11.9 Appointments and Retirements

Manpower of AERB is being augmented at different levels and through various channels in view of the expanding Nuclear Power Programme and an increasing number of Radiation Facilities in the country. The status of manpower for the year is as follows:

Table 11.1 Employees Joined AERB_

S. No.	Name	Designation	Date of Joining
1	Shri Pushpendra Singh	Technical Officer- D	16-01-2023
2	Shri Ujwal Narjinary	Upper Division Clerk	27-01-2023
3	Shri Rahul Mishra	Technical Officer- D	27/03/2023
4	Shri Ashok B. Gerira	Chief Administrative Officer	10-04-2023
5	Smt. Sujata S. Nair	Principal Private Secretary	20-04-2023
6	Smt. Siji Menon	Assistant	23-06-2023
7	Shri Alok Kumar	Scientific Officer - C	01-08-2023
8	Shri Manoj M. Jagasia	Chief Administrative Officer	08-09-2023
9	Shri Suman Kumar	Scientific Assistant - D	11-12-2023
10	Shri Kapil Deo Singh	Scientific Officer - G	29-12-2023

Table 11.2 Employees Retired/Transferred/Resigned from AERB

S. No.	Name	Designation	Date
1	Smt. Suchita Modi	Upper Division Clerk	02-01-2023
2	Shri R. U. Parmar	Scientific Officer - H	31/01/2023
3	Shri Abhinav Kumar	Scientific Officer - E	24/03/2023
4	Shri K. Venkat Subramanian	Chief Administrative Officer	10-04-2023
5	Shri R. J. Palamattam	Sr. Principal Private Secretary	18-04-2023
6	Shri V. Srinivasan	Assistant	30-04-2023
7	Smt. Pratibha Shelar	Assistant	30-04-2023
8	Dr. (Smt.) Shylamoni P.*	Scientific Officer - G	16-05-2023
9	Shri E.R. Titto	Scientific Officer - G	31-05-2023
10	Shri Pushpendra Singh	Technical Officer - D	26-05-2023
11	Shri Subhash M. Kodolkar	Scientific Officer - E	31-07-2023
12	Smt. Siji Menon	Assistant	30-08-2023
13	Shri Ashok Gerira	Chief Administrative Officer	13-09-2023
14	Shri Nikhil H	Scientific Officer - E	15-09-2023
15	Shri Kaushik Ghoshal	Scientific Officer - F	31-10-2023
16	Smt. Pushpa Wakte	Assistant	06-11-2023
17	Shri Mohammed Chand Pasha	Scientific Assistant - D	08-12-2023

* Demise

CHAPTER -12

EVENTS AND ACTIVITES IN AERB

EVENTS AND ACTIVITES IN AERB

Events and activities within an organization are the vibrant threads that weave together its culture, spirit, and sense of purpose. These gatherings serve as catalysts for collaboration, creativity, and connection among members. During the year, AERB conducted a significant number of events and activities, which are as follows:

12.0 Celebration of Republic Day

Shri Dinesh Kumar Shukla, Chairman, AERB unfurling the National Flag

On January 26, 2023, commemorating the 74th Republic Day, Chairman AERB unfurled the National Flag at AERB Headquarters premises. He addressed the audience, emphasizing the significance of Republic Day. He expressed his confidence in AERB employees and encouraged them to pursue excellence while upholding the national flag. He concluded his address by paying tribute to the great freedom fighters.

12.1 Swachhata Pakhwada

During February 16-28, 2023, AERB observed Swachhata Pakhwada and arranged various competitions and programs to promote the message of cleanliness. A Walkathon was conducted to inspire and raise widespread awareness about cleanliness and hygiene among AERB staff members and residents of Anushaktinagar. Additionally, a special cleanliness campaign was organized at Dadar Chowpatty Beach, Mumbai, and surrounding areas.

Glimpse of 74th Republic Day Celebrations

Glimpses of Programmes viz Essay Competition, Forest Conservation, Quiz Competition, Slogan Competition organized during Swachhata Pakhwada

Walkathon by Staff Members of AERB

Special Cleanliness Drive at Dadar Chowpatty Beach

12.2 National Safety Day

AERB celebrated the 52nd National Safety Day on March 9, 2023. The theme for this year's National Safety Day-2023 was "Our Aim-Zero Harm." Shri Ashok Raichur, Former Deputy General Manager of Safety Health Environment at HPCL Corporate Office and Former Technical Advisor at the National Safety Council, Mumbai, delivered a talk on "Accident Investigation, Root Cause Analysis Techniques, and Experience Sharing."

Shri S. B. Chafle, Executive Director, AERB, in his address emphasized identification of visible, hidden/ latent, root-contributory causes of the events to either eliminate or reduce the risk of recurrence of the event.

Shri Dinesh Kumar Shukla Chairman, AERB highlighted the importance of a safety culture in the operation of a facility. He emphasized that the safety culture in DAE units could be further strengthened to achieve the goal of zero accidents in the future.

As part of the event, a safety inspection of AERB office premises, including Niyamak Bhavan - A, B, and the construction site of Niyamak Bhavan - C, was conducted by a team of AERB officials.

Shri S.B. Chafle, Executive Director, AERB addressing Audience on National Safety Day

Shri D. K. Shukla, Chairman, AERB addressing Audience on National Safety Day

Shri Ashok Raichur, Former Deputy General Manager, Safety Health Environment, HPCL Corporate Office and Former Technical Advisor, National Safety Council, Mumbai

Delegates attending Activities during National Safety Day

12.3 International Women's Day Celebration

International Women's Day was celebrated at AERB on March 8, 2023, under the theme "Embracing Equity." The Chairman and Executive Director of AERB addressed the gathering on this occasion. Talks were delivered by Ms. Pushpalatha Chaurey, Corporate Trainer, and Ms. Anny Divya, Flight Commandant at Air India.

Glimpses of International Women's Day Celebration

12.4 World Yoga Day Celebration

AERB celebrated World Yoga Day on June 21, 2023. The theme for this year's International Yoga Day was "Yoga for Vasudhaiva Kutumbakam." Extracts from the Common Yoga Protocol, recommended by the Ministry of Ayurveda, Yoga & Naturopathy, Unani, Siddha, and Homoeopathy (AYUSH), were distributed to AERB staff for ready reference.

Shri S. B. Chafle, Executive Director, AERB lighting the Lamp during Yoga Session at AERB

Participants performing Yoga during World Yoga Day

12.5 Celebration of 77th Independence Day

AERB celebrated the 77th Independence Day on August 15, 2023. Shri Dinesh Kumar Shukla, Chairman AERB, hoisted the National flag at the AERB premises and addressed AERB officials. The AERB staff also took part in cultural programs during the celebration.

Glimpses of 77th Independence Day Celebration

CHAPTER -13

PROMOTION OF OFFICIAL LANGUAGE

PROMOTION OF OFFICIAL LANGUAGE

The Atomic Energy Regulatory Board (AERB) is dedicated to implementing the Official Language policy of the Government of India. Its goal is to foster a favourable environment for the use of Hindi and to motivate and encourage staff to perform their work in Hindi. The AERB has an established program to integrate Hindi into various official tasks. Additionally, AERB participates in the Joint Official Language Coordination Committee (JOLCC), which includes DAE units such as BRIT, Heavy Water Board, DCSEM, DPS, and the AERB itself.

13.0 Implementation of Official Language

Regular meetings of the Official Language Implementation Committee (OLIC) were held to discuss the effective use and implementation of the official language in AERB. Beyond routine official tasks and various translations into Hindi, AERB proactively engages in a series of activities to promote the official language. These activities include various publications, training programs, workshops, talks, and annual competitions. Highlights of the activities conducted in 2023 for the implementation and promotion of Hindi are given below.

13.1 Publications in Hindi

AERB issued Annual Report, e-Newsletters, press releases, licenses and authorisations in bilingual languages. Total 76,523 letters were issued in bilingual format.

13.2 Hindi Day Celebrations

World Hindi Day was celebrated on January 10, 2023, by the Joint Official Language Implementation Committee of AERB, DPS, DCSEM, HWB, and BRIT at the DAE Convention Centre in Mumbai. Shri Dinesh Kumar Shukla, Chairman of AERB, addressed the gathering, highlighting the increasing importance of Hindi as an official language. He emphasized that progress can be made by gradually incorporating Hindi into the education system and promoting its use in daily official activities.

National Hindi Day was celebrated at the DAE Convention Centre in Mumbai on September 27,

Shri D.K. Shukla, Chairman, AERB addressing the Gathering

Shri S.B. Chafle, Executive Director, AERB addressing the Gathering

2023. Shri S.B. Chafle, Executive Director of AERB, addressed the gathering and encouraged the use of simple and easy Hindi in daily activities. Certificates were awarded to the winners in various categories of Hindi activities.

13.3 Programmes for Promotion of Official Language

To promote the official language, AERB conducted Hindi slogan and essay writing competitions during Swachhata Pakhwada. In September 2023, AERB organized essay writing, poetry writing and recitation, dumb charades, interesting event narration, noting and drafting, and quiz competitions. AERB officials participated in joint Hindi workshops organized by DCSEM and BRIT. Additionally, AERB took part in the Joint Conference of the Western and Central Region, organized by the Department of Official Language in Mumbai.

13.4 Joint Hindi Workshop

A Hindi workshop was organized from January 17-19, 2023, under the aegis of the Joint Official Language Coordination Committee of the Atomic Energy Regulatory Board (AERB), Directorate of Purchase and Stores (DPS), Directorate of Construction, Services and Estate Management (DCSEM), Heavy Water Board (HWB), and Board of Radiation and Isotope Technology (BRIT). The workshop covered various topics, including the Official Language Policy of the Union, types of correspondence, standardization of spelling, and the National Pension Scheme.

13.5 Hindi Scientific Seminar

A Hindi scientific seminar was organized on April 21, 2023, to increase awareness about the usage of Hindi in scientific, technical, and regulatory matters.

Shri D.K. Shukla, Chairman, AERB and Shri S.B. Chafle, ED, AERB addressing during Hindi Scientific Seminar

13.6 Hindi Teaching Scheme

Under the Hindi Teaching Scheme, AERB staff were nominated for Parangat, Praveen, and Prabodh courses. In the current year, six individuals excelled in the Parangat examination, with one achieving success in Prabodh and two in Praveen.

CHAPTER -14

FINANCE

FINANCE

The Atomic Energy Regulatory Board (AERB) receives funds from the Government of India for meeting its revenue and capital expenditure. The Budget Estimates (BE) and Revised Estimates (RE) are prepared by AERB. Further, it monitors and controls expenditure based on the approved budget.

14.0 Annual Budget and Its Utilisation

Annual Budget for the year 2022-23 is given in Table 14.1

Table 14.1 Annual Budget for the year 2022-23 (Actual in crores)

Head	Budget Estimate	Revised Estimate	Actual Expenditure
Capital	44.72	35.00	31.97
Revenue	95.15	93.72	82.92

Capital expenditure was incurred towards the development of Niyamak Bhavan – C, the upgradation of engineering services and computing systems, the construction of the SRI Engineering Hall, the setting up of experimental facilities, the augmentation of research labs, and the refurbishment of the SRI guest house.

Revenue expenditure includes salaries, allowances, rewards, domestic travel, annual maintenance, honorarium for consultants/specialists, and grants-in-aid schemes.

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11. B.S.Manisha Singh, Nabin Kumar Dhal, Manish Kumar, D.K. Mohapatra, H.Seshadri and Monalisha Nayak, "Retaliation of Alstoniascholaris (L.) R.Br. to caesium and strontium in hydroponics: effect on morpho physiology and induction of enzymatic defence", Environmental Monitoring and Assessment, (2023), 195:703, pp 1-

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ABBREVIATIONS

ACNRS	Advisory Committee on Nuclear and Radiation Safety
ACPSR	Advisory Committee for Project Safety Review
ACS	Advisory Committee on Security
ACTREC	Advanced Centre for Treatment, Research and Education in Cancer
AEC	Atomic Energy Commission
AERB	Atomic Energy Regulatory Board
AFR	Away From Reactor
AAFR	Additional Away From Reactor
AGFS	AERB Graduate Fellowship Scheme
AIIMS	All India Institute of Medical Sciences
ALARA	As Low as Reasonably Achievable
ALSC	Accelerator and Laser Safety Committee
AMD	Atomic Minerals Directorate for Exploration and Research
ARPF	Agricultural and Radiation Processing Facility
ASCE	Assistant Shift Charge Engineer
AOO	Anticipated Operational Occurrences
BARC	Bhabha Atomic Research Centre
BAERA	Bangladesh Atomic Energy Regulatory Authority
BE	Budget Estimates
BDBE	Beyond Design Basis Event
BHAVINI	Bharatiya Nabhikiya Vidyut Nigam
BHEL	Bharat Heavy Electricals Limited
BWR	Boiling Water Reactor
BRIT	Board of Radiation & Isotope Technology
BSM	Beach Sand Minerals
CDB	Collective Dose Budget
CDA	Core Disruptive Accident
CFTF	Compartment Fire Test Facility
CSIR	Council of Scientific & Industrial Research
CSTS	Calandria Side Tube Sheet
CWMF	Centralised Waste Management Facilities
CE	Control Engineer
CESC	Civil Engineering Safety Committee
CFD	Computational Fluid Dynamics
CFVS	Containment Filtered Venting System
CHF	Critical Heat Flux
CMG	Crisis Management Group
CNS	Convention on Nuclear Safety
COMREF	Core Melt Retention Facility
COSTRAM	Committee for Safe Transport of Radioactive Material
CORAL	Compact Reprocessing of Advanced Fuels in Lead Cell
CPIO	Central Public Information Officer
CPGRAMS	Centralized Public Grievance Redress and Monitoring system
CPSAR	Control and Protection System Absorber Rods
CRENRAF	Committee for Review of Exposure Cases in Nuclear Fuel Cycle and Radiation Facilities
CRSA	Committee for Reviewing Security Aspects
CSRP	Committee for Safety Research Programmes

CT	Calandria Tubes / Computed Tomography
DAE	Department of Atomic Energy
DBA	Design Basis Accident
DCSEM	Directorate of Construction, Services & Estate Management
DFRP	Demonstration Fast Reactor Fuel Reprocessing Plant
DHOA	Di Hexyl Octanamide
DPP	Document Preparation Profile
DPS	Directorate of Purchase and Stores
DPIIT	Department for Promotion of Industry and Internal Trade
DRI	Directorate of Regulatory Inspection
DRP&E	Directorate of Radiation Protection and Environment
DSS	Decision Support System
ECCS	Emergency Core Cooling System
ECIL	Electronics Corporation of India Limited
EFPD	Effective Full Power Day
EP	Emergency Protection
EGCC	Expert Group on Coolant Channels
EDX	Energy Dispersive X-ray
e-LORA	electronic Licensing of Radiation Applications
EMCCR	En-Masse Coolant Channel Replacement
EMFR	En-masse Feeder Replacement
EP	Emergency Protection
EPR	Emergency Preparedness & Response
ER	Event Reports
ERRC	Eastern Regional Regulatory Centre
ERMO	Emergency Response Monitoring Organization
ESL	Environmental Survey Laboratories
FAC	First Approach to Criticality
FBR	Fast Breeder Reactor
FBTR	Fast Breeder Test Reactor
FCF	Fuel Cycle Facilities
FED	Field Exercise and Demonstration
FFTF	Fast Flux Test Facility
FHIC	Feeder Header Insulation Cabinet
PFFF	PHWR Fuel Fabrication Facility
FOAK	First-of-A-Kind
FP	Full Power
FPC	First Pour of Concrete
FR	Frequency Rate
FTIR	Fourier Transform Infrared Spectroscopy
GHAVP	Gorakhpur Haryana Anu Vidyut Pariyojana
GI	Ground Improvement
GIC	Gamma Irradiation Chamber
GRAPF	Gamma Radiation Processing Facilities
GSR	General Safety Requirements
GTR	Gantry Treatment Room
HS&EG	Health, Safety and Environment Group
HOT	Human Organisation & Technical Factors
HWP	Heavy Water Plant
HQ	Head Quarter
I&C	Instrumentation & Control
IAEA	International Atomic Energy Agency

IARPF	Industrial Accelerator Radiation Processing Facility
IC	Inner Containment/Initiating Conditions
ICCR	Integrated Command Control and Response
ICRP	International Commission on Radiological Protection
IFSB	Interim Fuel Storage Building
IGCAR	Indira Gandhi Centre for Atomic Research
IGSCC	Inter Granular Stress Corrosion Cracking
II	Injury Index
IIMC	Indian Institute of Mass Communication
IIT	Indian Institute of Technology
ILRT	Integrated Leak Rate Test
IMS	Integrated Management System
INES	International Nuclear and Radiological Event Scale
IPHWR	Indian PHWR
IR	Industrial Radiography
IR	Incidence Rate
IREL	IREL(India) Ltd.
IRRS	Integrated Regulatory Review Service
IRGD	Ionising Radiation Gauging Devices
IRED	Industrial Radiography Exposure Device
ISC	Indian Science Congress
ISI	In-service Inspection
ISO	International Organisation for Standardisation
ISOMED	Irradiation Sterilization of Medical Products
IVR	In-Vessel Retention
JOLCC	Joint Official Language Coordination Committee
KAPS	Kakrapar Atomic Power Station
KAPP	Kakrapar Atomic Power Project
KGS	Kaiga Nuclear Power Station
KAMINI	Kalpakkam Mini Reactor
KKNPP	Kudankulam Nuclear Power Project
KMS	Knowledge Management System
KMML	Kerala Minerals and Metals Ltd
LASER	Light Amplification by Stimulated Emission of Radiation
LED	Light-emitting diode
LINAC	Linear Accelerators
LOCA	Loss of Coolant Accident
LSSR	Limited Scope Safety Review
LWR	Light Water Reactor
MAPS	Madras Atomic Power Station
MAL	Main Air Lock
MCP	Main Coolant Pipelines
MEE	Major Equipment Erection
MoU	Memorandum of Understanding
MRTDDF	Magnesium Recycling Technology Development & Demonstration Facility
MSP	Mineral Separation Plants
MWe	Mega Watt Electrical
NDT	Non-Destructive Testing
NDCT	Natural Draft Cooling Tower
NF	Nuclear Facility
NG	Nucleonic Gauges
NRB	Nuclear Recycle Board
NRRC	Northern Regional Regulatory Centre
N&IF	Nuclear & Industrial Facilities
NAPS	Narora Atomic Power Station
NB	Nuclear Building

NCRI	National Conference on Regulatory Interface
NDMA	National Disaster Management Authority
NEA	Nuclear Energy Agency
NFC	Nuclear Fuel Complex
NOC	No Objection Certificate
NORM	Naturally Occurring Radioactive Material
NPCIL	Nuclear Power Corporation of India Limited
NPP	Nuclear Power Plant
NPSD	Nuclear Projects Safety Division
NRE	Nuclear and Radiological Emergency
NREMC	Nuclear and Radiological Emergency Monitoring Centre
NRF	Nuclear & Radiation Facility
NSAD	Nuclear Safety Analysis Division
NSDF	Near Surface Disposal Facility
NSWS	National Single Window System
OCES	Orientation Course for Engineering Graduates and Science Post Graduates
OESC	On-Site Emergency Support Centre
OHSC	Occupational Health Safety Committee
OJT	On-Job-Training
OLIC	Official Language Implementation Committee
O&M	Operation & Maintenance
OPSD	Operating Plants Safety Division
OSCOM	Orissa Sand Complex
OSEE	Off-site Emergency Exercise
PARF	Particle Accelerator Research Facilities
PCCS	Passive Containment Cooling System
PCRDs	Passive Catalytic Recombiner Devices
PCRD	Passive Catalytic Recombiner Device
PDSC	Project Design Safety Committee
PEE	Plant Emergency Exercise
PET	Positron Emission Tomography
PFBR	Prototype Fast Breeder Reactor
PFFF	PHWR Fuel Fabrication Facility
PHTS	Primary Heat Transport System
PHWR	Pressurized Heavy Water Reactor
PMS	Personal Monitoring System
PSI	Pre-Service Inspections
PSR	Periodic Safety Review
PWR	Pressurised Water Reactor
QA/QC	Quality Assurance/Control
R&D	Research & Development
RAPP	Rajasthan Atomic Power Project
RAPS	Rajasthan Atomic Power Station
RB	Reactor Building
RCA	Root Cause Analysis
RCL	Radio Chemistry Laboratory
REGDOC	Regulatory Safety Documents
RERD	Radiation Emergency Response Director
RE	Revised Estimates
RF	Radiation Facility / Radio Frequency
RI	Regulatory Inspection
RIH	Reactor Inlet Header
RML	Radio Metallurgy Laboratory
RR	Rawatbhata Rajasthan
RR	Research Reactor
RPF	Radiation Processing Facility
RPV	Reactor Pressure Vessel
RRC	Regional Regulatory Centres

RRCAT	Raja Ramanna Centre for Advanced Technology
RSD	Radiological Safety Division/ Refuelling Shutdown
RSO	Radiological Safety Officer
RCL	Radio Chemistry Laboratory
RTI	Right To Information
ROH	Reactor Outlet Header
RU	Reprocessed Uranium
SARCAR	Safety Review Committee for Applications of Radiation
SARCOP	Safety Review Committee for Operating Plants
SBO	Station Blackout
SC	Safety Code
SCCI&CS	Standing Committee on Control Instrumentation & Computer Based Systems
SCE	Shift Charge Engineer
SCHTF	Safety Committee for Hadron Therapy Facilities
SCRAM	Safety and Control Rod Accelerated Movement
SCRF	Superconducting RF Cavity
SDDP	Safety Document Development Proposal
SDRP	Safety Document Revision Proposal
SDS	Shutdown System
SEE	Site Emergency Exercise
SEM	Scanning Electron Microscope
SER	Significant Event Report / Site Evaluation Report
SFP	Spent Fuel Pool
SFR	Sodium-cooled Fast Reactors
SG	Safety Guide/Steam Generator
SGDHR	Safety Grade Decay Heat Removal System
SNS	Single-phase Natural Circulation Stage
SM	Safety Manual
SOT	Site Observer Team
SPECT	Single Photon Emission Computed Tomography
SPP	Solvent Production Plant
SR	Severity Rate
SRI	Safety Research Institute
SRRC	Southern Regional Regulatory Centre
SS	Safety Standard
TAPS	Tarapur Atomic Power Station
TB	Turbine Building
TBP	Tri Butyl Phosphate
TBq	Tera Baqurrel
TiAP	Tri iso Amyl Phosphate
TOPO	Tri Octyl Phosphine Oxide
TT	Table-Top
TPA	Tons Per Annum
UC	Uranium Carbide
UCIL	Uranium Corporation of India Limited
UJDSR	Nuclear Regulatory Authority of the Slovak Republic
USNRC	United States Nuclear Regulatory Commission
VSSP	Versatile Solvent Synthesis Plant
VDPP	Versatile Deuterated compounds Production Plant
VECC	Variable Energy Cyclotron Centre
VVER	Vodo-Vodyanoi Energetichesky Reactor
WL	Well Logging
XIC	X-ray Irradiation Chamber
XRD	X-ray Diffraction
ZC	Zirconium Complex
ZFF	Zircaloy Fabrication Facility

INTERNATIONAL NUCLEAR AND RADIOLOGICAL EVENT SCALE (INES)

INES Level	Name of the Events
MAJOR ACCIDENT LEVEL 7	• Major release of radioactive material with widespread health and environmental effects requiring implementation of planned and extended countermeasures.
SERIOUS ACCIDENT LEVEL 6	• Significant release of radioactive material likely to require implementation of planned countermeasures.
ACCIDENT WITH WIDER CONSEQUENCES LEVEL 5	• Limited release of radioactive material likely to require implementation of some planned countermeasures. • Several deaths from radiation. • Severe damage to reactor core. • Release of large quantities of radioactive material within an installation with a high probability of significant public exposure. This could arise from a major criticality accident or fire.
ACCIDENT WITH LOCAL CONSEQUENCES LEVEL 4	• Minor release of radioactive material unlikely to result in implementation of planned countermeasures other than local food controls. • At least one death from radiation. • Fuel melt or damage to fuel resulting in more than 0.1% release of core inventory. • Release of significant quantities of radioactive material within an installation with a high probability significant public exposure.
SERIOUS INCIDENT LEVEL 3	• Near accident at a nuclear power plant with no safety provisions remaining. • Lost or stolen highly radioactive sealed source. • Misdelivered highly radioactive sealed source without adequate procedures in place to handle it. • Exposure rates of more than 1 Sv/h 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.
INCIDENT LEVEL 2	• Significant failures in safety provisions but with no actual consequences. • Exposure of a member of the public in excess of 10 mSv. • Exposure of a worker in excess of the statutory annual limits. • Radiation levels in an operating area of more than 50 mSv/h. • 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 a highly radioactive sealed source.
ANOMALY LEVEL 1	• Minor problems with safety components with significant defence-in-depth remaining. • Overexposure of a member of the public in excess of statutory annual limits. • Low activity lost or stolen radioactive source, device or transport package.
BELOW SCALE/ Level 0	No safety significance

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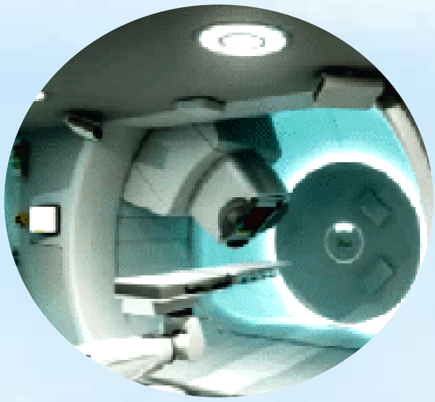

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