सत्यमेव जयते

Atomic
Energy
Regulatory
Board

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Azadi Ka Amrit Mahotsav

विकिरण से सुरक्षित भारत

ATOMIC ENERGY REGULATORY BOARD

ANNUAL REPORT 2021

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 of which two are whole time members including the Chairman. The other whole-time member is the Executive Director of the AERB Secretariat who is an ex-officio member of the Board. The other four members are eminent experts from various disciplines relevant to the mandate of the Board. The Board is assisted by a non-member Secretary who is an employee of the Secretariat. The Board is responsible to Atomic Energy Commission (AEC). AERB carries out its functions through highly qualified work force and specialist committees under the guidance of the Board. 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).

The ACPSR advises to AERB on issuance of consents at different stages of projects of the Department of Atomic Energy (DAE) under the purview of AERB, after reviewing the submissions made by the project authorities, based on the recommendations of the associated Project Design Safety Committees (PDSC). The SARCOP carries out safety surveillance and recommends enforcement of safety stipulations in the operating units of DAE under the purview of AERB. SARCAR recommends measures to enforce radiation safety in medical, industrial and research institutions, which use radiation and radioactive sources. AERB receives advice on development of safety codes / guides and on generic and specific safety issues concerning the safety of nuclear and radiation installations from ACNRS, Advisory Committee on Security (ACS) advises AERB on nuclear security aspects and Occupational Health and Safety Committee (OHSC) advises AERB on occupational health safety matters.

The administrative and regulatory mechanisms are in place to ensure multi-tier review of all 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 has a Safety Research Institute (SRI) located at Kalpakkam, Tamil Nadu, which carries out research in safety related topics and organises seminars, workshops and discussion meetings. Regional Regulatory Centres (RRCs) of AERB set up at Kolkata, Chennai and Delhi carry out regular surveillance of the radiation facilities in eastern, southern and northern zones respectively. AERB Headquarters comprises of nine Technical Divisions including Legal & Security Cell. Executive Director, Directors of Groups and Heads of Directorates / Divisions constitute the Executive Committee, which meets periodically and takes decisions on important matters related to the functioning of the organisation. Integrated Management System (IMS) of AERB integrates all the processes required for fulfilling its functions into an integrated framework enabling AERB to achieve its mission.

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 Substance) Rules, 1984.

Atomic Energy (Radiation Processing of Food & Allied Products) Rules, 2012.

सत्यमेव जयते

GOVERNMENT OF INDIA

ATOMIC ENERGY REGULATORY BOARD

ANNUAL REPORT 2021

Niyamak Bhavan, Anushakti Nagar
Mumbai- 400 094

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 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 Programme, 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 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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LIST OF TABLES

MISSION AND VISION OF AERB

MISSION

The mission of the 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 the 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. Organisational Strategy is aimed to establish an Integrated Management system (IMS) by effective integration of all regulatory and management processes and coordination among interdependent processes. The Strategy also includes the basis for IMS implementation, assessment and continual improvement are as follows.

- Developing an organisational structure commensurate with the IMS.
- 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 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 resources 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 bases, 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 focussed 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 G. Nageswara Rao

MEMBERS

Prof. Devang V. Khakhar
Professor,
Indian Institute of Technology
Bombay, Mumbai

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

Shri C.S. Varghese
Ex-Officio Member
Chairman, SARCOP

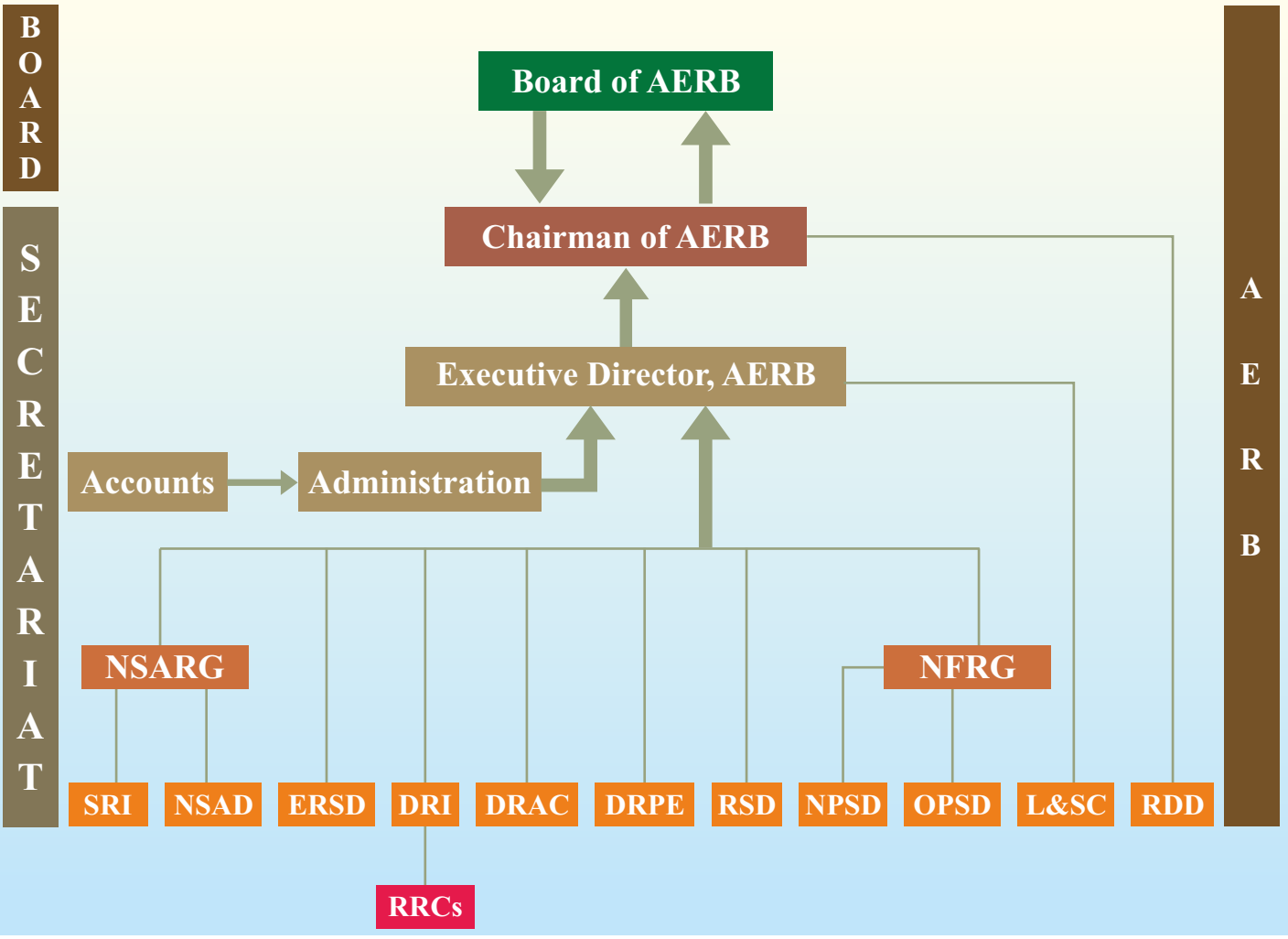
Dr. G. K. Rath
Ex Professor & Head
Department of Radiation Oncology,
AIIMS, New Delhi
Chief, Dr. B.R. Ambedkar Institute Rotary
Cancer Hospital, National Cancer Institute
Jhajjar, Haryana

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

SECRETARY

Dr. A. U. Sonawane
Secretary to the Board, and Head, DRA&C, AERB

ORGANISATION CHART OF AERB



NFRG	Nuclear Facilities Regulation Group
NSARG	Nuclear Safety Analysis and Research Group
SRI	Safety Research Institute, Kalpakkam
NSAD	Nuclear Safety Analysis Division
ERSD	Emerging Regulatory Strategy Division
DRI	Directorate of Regulatory Inspection
DRAC	Directorate of Regulatory Affairs and Communications
DRPE	Directorate of Radiation Protection and Environment
RSD	Radiological Safety Division
NPSD	Nuclear Projects Safety Division
OPSD	Operating Plants Safety Division
L&SC	Legal & Security Cell
RDD	Resources and Documentation Division
RRCs	Regional Regulatory Centres

KEY INFORMATION OF THE YEAR 2021

350 Staff Members	**04** Board Meetings	**36** Projects Safety Committee Meetings
82 Operating NPP Meetings	**14** FCF & other Industrial Facilities Meetings	**08** Radiation Facilities Meetings
6 Renewal of Licences (NPP)	**54** Responses Submitted Against Parliamentary Questions	**16,230** Licences Issued (Radiation Facilities)
3,838 Permissions for procurement of Radioactive Sources	**12,637** Permissions for Procurement of Radiation Generating Equipment	**94,773** X-ray Equipment Licensed in e-LORA till December 2021
178 Operating Personnel Licensed (NPP)	**18** Operating Personnel Licensed (RR)	**3,525** Approvals for RSO (RF)
18 Inspections (Nuclear facilities - under Construction)	**29** Inspections (FCF & other Industrial Facilities)	**49** Inspections (Operating NPP)
758 Inspections (Radiation Facilities)	**17** Scientific Publications	**21** Safety Meet/Theme Meetings/ Colloquia/Invited Talk on Nuclear and Radiation Facilities
16,637 Bilingual letters Issued	**02** REGDOCs published and **51** REGDOCs in various stages of Development	**142** RTI Queries Replied

HIGHLIGHTS OF ACTIVITIES

Atomic Energy Regulatory Board (AERB) continued the safety monitoring and regulatory supervision of nuclear and radiation facilities under its purview, including operating nuclear power plants, nuclear power projects (under site evaluation/under construction), the nuclear fuel cycle facilities, research units and large number of radiation facilities spread across the country. AERB issued two important Safety Directives, one defining the 'Radioactive Substance' and the other on 'Exemption of Radiation Generating Equipment'. These Directives will play an important role in deciding the scope and domain of regulatory activities by AERB.

All the operating nuclear power plants and fuel cycle facilities under AERB's purview operated safely during the year, and radioactive discharges and radiation doses to occupational workers were well within the prescribed limits. The radioactive releases from nuclear power plants remained well within limits authorised by AERB. The effective dose to the public around the nuclear power plant sites was far less than the specified annual limit of 1 mSv.

KEY ACHIEVEMENTS DURING THE YEAR 2021

1 Issuance of Licences/Consents of Nuclear Power Projects/Fuel Cycle Facilities (under Construction)

(I) Siting Consent for away from reactor (AFR) Spent Fuel Storage Facility at KKNPP-1&2 and KKNPP-3&4.

(ii) Consent for First Pour of Concrete (FPC) for Kudankulam Nuclear Power Plant (KKNPP-5&6).

(iii) Permission for construction of Safety Related Pump House(SRPH), FIRE Water Pump House (FWPH) of GHAVP-1&2 and Onsite Emergency Support Centres (OESC) at Kaiga and TAPS sites.

2 Issuance of Licences of Operating Nuclear Facilities

(i) Renewal of Licence for operation of three nuclear power plants viz. KKNPP-1&2, TAPS-1&2 and TAPS-3&4.

(ii) Renewal of Licence for operation of Banduhurang mine Turamdih mill and Tummalapalle Mill.

(iii) Renewal of Licence for operation of Rare Earth Extraction Plant (REEP) at IREL (India) Ltd., OSCOM and permission for setting up a separate facility for processing lean Rare Earth (RE) Chloride Solution at Rare Earth Extraction Plant (REEP) at Indian Rare Earths Limited (IREL), OSCOM.

(iv) Renewal of Licence for operation of HWP- Baroda and Zirconium Complex-Pazhayakayal and TDP-Chembur and ECIL-Tirupathi under The Factories Act, 1948.

(v) Renewal of Licence for operation to Technology Demonstration Plant (TDP) of Heavy Water Board (HWB) located at M/s Rashtriya Chemicals & Fertilizer Ltd. (RCF) Chembur, Mumbai and ECIL-Tirupati.

3 Issuance of Licences/Consents for Radiation Facilities

(i) 16,230 Licences were issued to radiation facilities involved in use of ionising radiation in medical, industrial and research activities.

(ii) 3,838 permissions were issued for procurement of radioactive sources (imported and indigenous).

(iii) 11,995 permissions were issued for procurement of diagnostic X-ray equipment.

(iv) Approval for 3,525 Radiological Safety Officers (RSO) were issued for various radiation facilities.

4 Regulatory Oversight for Nuclear and Radiation Facilities

(i) During COVID-19 pandemic, AERB developed and further strengthened remote regulatory inspection process to continue its regulatory oversight over the licensed activities/facilities.

(ii) Three Special regulatory inspections(RI) of KAPP-3&4 were carried out to verify activities related to implementation of ECN and proposed modifications and their implementations in KAPP-3&4.

(iii) The AERB Site Observers Team (SOT) continuously observed the twelve operating NPPs, two under commissioning and five under-construction units.

(iv) Ninety-six inspections of nuclear power projects, operating NPPs, and fuel cycle facilities under the purview of AERB covering safety (nuclear, radiological & industrial) and security aspects were carried out.

(v) 758 inspections of medical, industrial and research radiation facilities were carried out.

5 Enforcement Actions in Nuclear and Radiation Facilities

(i) Show-cause notice was issued to an Industrial Radiography facility located at Faridabad for involving an untrained person in conducting radiography work.

(ii) Show-cause notice was issued to one of the manufacturers/suppliers of X-ray based equipment for violating the regulatory requirements specified in Atomic Energy Radiation Protection Rules AE(RP)R, 2004.

(iii) Warning letters were issued to four radiation facilities for non-compliance to regulatory requirements and unsafe radiation work practices.

6 Emergency Preparedness and Response (EPR) at NPPs

(i) The Offsite Emergency Exercise (OSEE) framework was strengthened by conducting two different exercises, viz. Table-Top (TT) exercise and Integrated Command Control and Response(ICCR) OSEE.

(ii) Integrated Command Control and Response(ICCR) Offsite Emergency Exercises were observed remotely. In addition, some exercises were also reviewed based on reports submitted by the facilities subsequent to completion of the exercises.

(iii) Site Emergency Exercises were carried out at seven NPP sites. The ICCR OSEE was conducted at four NPP sites, viz. Tarapur, Narora, Kakrapar, and Kalpakkam. These exercises were conducted following a revised methodology finalized by all stakeholders (NDMA, NPCIL, CMG-DAE, BARC, and AERB). NPP Staff and Senior Management, District Authorities, DAE-CMG, and RERD-BARC participated in these exercises.

7 Regulatory Safety Documents (REGDOCs)

(i) Two REGDOCs, viz. Safety Guide on 'Regulatory Control of Radioactive Discharges to the Environment and Disposal of Solid Waste', and Safety manual on 'Methodology for Radiological Impact Assessment of Nuclear Power Plants under Postulated Accident Conditions', were published.

(ii) Eight draft Safety Standards and Documents Preparation Profiles (DPP) of IAEA were reviewed and commented.

(iii) Fifty-one REGDOCs are under different stages of development/ revision.

8 Safety Analysis, Research and Development

(i) A seismic soil structure interaction analysis of Station Auxiliary Building was carried out in specialized software System for Analysis of Soil Structure Interactions (SASSI). The outcome of the study was used to compare the findings of similar analysis submitted by NPCIL for design safety review.

(ii) Numerical Simulation of pile behaviour at Gorakhpur Haryana Anu Vidyut Pariyojana (GHAVP) site with respect to the test data was carried out. This study was undertaken to calibrate the numerical model using the results of vertical pile load test at GHAVP site.

(iii) Computational Fluid Dynamics (CFD) and Computational Solid Mechanics (CSM) coupling methodology were developed in ANSYS Workbench for estimating the associated deflection of fuel bundle.

(iv) A Core Melt Retention Facility (COMREF) was established at Engineering Hall, Safety Research Institute (SRI)-AERB at Kalpakkam to investigate the in-vessel retention capability of calandria vessel of PHWRs during postulated severe accident conditions.

9 Public Information and Safety Promotional Activities for Stakeholders

(i) Fifth National Conference on Regulatory Interface (NCRI-2021), with theme on 'Self- Regulation for Safety' was conducted in hybrid mode.

(ii) A theme meeting on "Improving Safety and Security of Computer Based C&I systems used in Systems Important to Safety in NPPs" was organised in virtual mode.

(iii) Webinars on various topics, viz. "Corium Retention in Indian Nuclear Reactors during Postulated Severe Accident", 'Security of Radioactive Material/Sources', Societal Benefits of Radiation Technology and Safety Aspects" and Safety Review and Assessment of Civil structures and containments of Nuclear Power Plants" were organised in virtual mode.

(iv) Awareness programme for several radiation practices, viz. 'Safe Handling of Nucleonic Gauges', Radiation Protection in Diagnostic Radiology and Proper Use of TLD badge" for X-ray Technologists and Medical practitioners in Diagnostic Radiology (DR) were organised through virtual mode.

(v) A workshop on 'Life Cycle of PHWR Coolant Channels' was organized by SRI-AERB at Kalpakkam.

10 International Cooperation

(i) AERB participated in the 2nd Joint Committee Meeting between Vietnam Agency for Radiation and Nuclear Safety (VARANS) and India held virtually on March 18, 2021.

(ii) 65th IAEA General Conference was held at Vienna during September 20 - 24, 2021. Chairman AERB, as part of Indian delegation participated in the conference.

(iii) The bilateral arrangement between the Nuclear Safety Authority (ASN) of France and AERB for the exchange of technical information and cooperation in the regulation of nuclear safety and radiation protection was renewed on September 21, 2021 in Vienna.

(iv) A virtual meeting was held on October 05, 2021 between Office of Radiological Security (ORS) of US DoE and AERB. The discussion primarily focussed on the security aspects of radioactive sources and possible areas of collaboration between ORS and AERB.

(v) International Regulatory Review Service (IRRS) IAEA-IRRS extended follow-up mission planned to be conducted in June 2022.

11 Public Accountability

(i) AERB submitted responses to DAE to 54 parliamentary questions.

(ii) All grievances pertaining to AERB received through Centralized Public Grievance Redressal and Monitoring System (CPGRAMS) portal were addressed in time.

(iii) 142 RTI questions were replied during the period.

12 Human Resource Development

(i) Augmentation of manpower continued with recruitment of 25 personnel in various categories.

(ii) In its endeavour to support the competency building programme in Nuclear Law, AERB officers actively participated and delivered online lectures in the Certification Course in Nuclear Law and Energy organized by Nuclear Law Association and TERI University.

(iii) AERB organised a training courses towards competency development/enhancement of AERB Staff on 'Nuclear Power Plant Containment Safety' and training course on 'Accelerators' commencing in the hybrid mode.

(iv) AERB, jointly with International Centre for Theoretical Physics (ICTP) - IAEA, organised a training course on Theoretical Foundations and Application of Computational Fluid Dynamics in Nuclear Engineering.

13 Infrastructure Development

(i) Southern Regional Regulatory Centre (SRRC), Chennai was made fully functional from the new building. Furniture and IT infrastructure were established at SRRC, Chennai.

(ii) Civil construction of Eastern Regional Regulatory Centre (ERRC), Kolkata building is completed.

(iii) A new DAE office building is planned at Sector-9 Dwarka, New Delhi. AERB's Northern Regional Regulatory Centre (NRRC) is planned to be housed in this building. The architectural concept plan of this building is in finalisation stage.

(iv) Construction of Niyamak Bhavan-C building at Head Quarter, Mumbai is in advance stage of completion.

(v) Towards conservation of energy at Niyamak Bhavan-A, Mumbai, all conventional luminaries have been replaced by LED lights. In addition to it, as part of the green energy initiative, a solar power plant of 25 kWp was installed on rooftop.

(vi) Enhanced IT infrastructure has been provided and commissioned to facilitate the smooth functioning of hybrid mode for remote regulatory inspection and interactions for conducting virtual meets.

14 Promotion of Official Language

(i) "Hindi Day Celebration" was organized virtually during the COVID-19 pandemic.

(ii) As a part of celebration of 'Azadi Ka Amrit Mahotsav', Hindi Webinar on 'Safe Work Practices' and 'Emergency Preparedness in Industrial Radiography' and various competitions like

- Hindi essay writing competitions,
- Rangoli-cum-Hindi-Caption-Hindi Speech Competition,
- Interesting event writing competition,
- Self-written poetry competition,
- Story competition,
- Hindi essay competition etc. were organised

(iii) An AERB Officer delivered a lecture in Hindi in the Awareness Programme organised by Institute of Physics (IOP), Bhubaneswar on a topic "Safe Work Practices and Emergency Preparedness in Industrial Radiography".

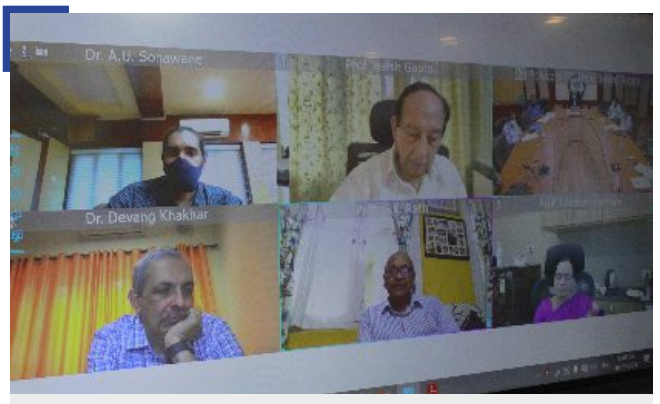
(iv) 16,637 bilingual letters were sent (English and Hindi).

EXECUTIVE SUMMARY

During the year 2021, Atomic Energy Regulatory Board (AERB) continued to monitor safety aspects of all facilities and activities involved in nuclear energy and applications of ionising radiations under its purview. AERB along with the Technical Divisions continued to carry out its functions with the support of various safety committees and specialist committees, under the guidance of the Board of AERB, which is the decision making body on policy matters for regulation of nuclear and radiation facilities and associated activities.

The Board met four times during the year 2021 and three of these meetings were held through video-conferencing. The Board was regularly apprised of the safety status of Nuclear Power Projects/ Fuel Cycle Facilities under construction /commissioning, operating Nuclear Power Plants, Nuclear Fuel Cycle Facilities and large number of Radiation Facilities in the country. The important safety clearances approved by the Board during the year after requisite safety reviews include permission for First Pour of Concrete (FPC) to KKNPP-5&6 at Kudankulam, Tamil Nadu and Siting Consent for Away From Reactor (AFR) Spent Fuel Storage Facilities for KKNPP-1&2 and KKNPP-3&4. The Board also has approved the revisions made in the Level-I document, i.e. top level document of Integrated Management System (IMS) of AERB and has concurred with the document on 'Transaction of Business of the Board'.

Board Meeting in Progress in Hybrid Mode



Board Meeting in Progress through Video-Conferencing

Safety Surveillance of Nuclear Power Projects

AERB had issued clearance for First Pour of Concrete (FPC) for KKNPP-3&4 on June 23, 2017 with certain stipulations. AERB extensively reviewed the design safety aspects of KKNPP-3&4. Presently, civil construction work is in progress at KKNPP-3&4 and the stipulations made during FPC consent are being followed up. Erection of Core Catcher, for which permission was issued earlier, was successfully completed. AERB also issued Consent for FPC for KKNPP-5&6 on May 12, 2021. Various design & analysis documents w.r.t. 'Regulatory Hold Points' (RHPs) of FPC consent are being reviewed.

Prototype Fast Breeder Reactor (PFBR) project is currently in commissioning stage. Safety review of Phase-A commissioning activities is in progress. Review & assessment of commissioning procedures and reports pertaining to fuel handling system are in progress. Emergency Action Levels (EALs), forming part of the Plant Emergency Preparedness and Response manual were reviewed.

Currently the 700 MWe PHWR unit at Kakrapar, Gujarat KAPP-3 is under Phase–C commissioning stage (within the permission to operate the Reactor up to 50% FP). Most of the Phase-C commissioning tests up to 50%FP have been completed. During power operation, higher area temperatures, beyond that considered in the design, were observed in some of

the areas within the reactor building. To address this, certain modifications in the ventilation arrangement and the structural steel platform above the fuelling machine vaults were proposed. AERB permitted NPCIL to implement the identified modifications after the necessary safety reviews. While the issue was under review for finalising the corrective actions, the unit was being operated at low power (up to 0.85%FP with PHT temperature below 50ºC).

In RAPP-7&8, civil construction and erection of equipment/components and pre-commissioning activities are in progress. RAPP-7&8 has been asked to update the commissioning procedures based on the commissioning review and experience of KAPP-3&4.

Consent for first pour of concrete for 2X700 MWe PHWR units at Gorakhpur, Haryana (GHAVP-1&2) was given by AERB on November 18, 2020. Subsequently construction of foundation piles in nuclear building area has been completed and tests to ascertain the integrity and capacity of the constructed piles were carried out. AERB undertook review of the test reports. NPCIL actions to address AERB's review observations on the test reports are currently under review.

View of KKNPP-3&4

Permission to start construction of Safety Related Pump House (SRPH) & Fire Water Pump House (FWPH) of GHAVP-1&2 was issued on February 2, 2021 after safety reviews. Subsequently, permission was issued for construction of Fuel Oil Storage Area (FOSA) and Ventilation Stack structures on December 29, 2021. AERB had also extended the validity period of Excavation Consent of GHAVP-1&2 up to March 31, 2023.

NPCIL has proposed to construct two 700 MWe PHWRs at Kaiga site where four 220 MWe PHWRs are already in operation. The proposed KAIGA-5&6 NPPs are similar to the ones being built at GHAVP-1&2, except for certain site specific changes. NPCIL has submitted the application for Excavation Consent for KAIGA-5&6, which is under review by AERB.

Application for Siting Consent of Mahi Banswara Rajasthan Atomic Power Project Units 1 to 4 (MBRAPP - 1 to 4) was submitted to AERB. Adequacy review of the application by AERB indicated that additional information was needed before admittance of the application by AERB.

Earlier in April 2016 NPCIL had submitted application for siting consent of 2 x 700 MWe PHWR at Chutka Village of Mandla District in Madhya Pradesh (CMPAPP). In absence of identified submissions, the NPCIL siting application was considered as returned to the applicant and the same was communicated to NPCIL.

Safety Surveillance of Nuclear Fuel Cycle Facilities and other related Industrial Facilities (Projects)

AERB issued Siting Consent for Away From Reactor (AFR) Spent Fuel storage facilities at KKNPP-1&2 on May 21, 2021 and KKNPP-3&4 on August 23, 2021 respectively.

AERB continued the safety review of commissioning activities at Demonstration Fuel Reprocessing Plant (DFRP) being set up at Kalpakkam for reprocessing of spent fuel from Fast Breeder Test Reactor (FBTR). Erection of equipment is in progress for head-end facility of DFRP.

Construction work of plant buildings of PHWR Fuel Fabrication Facility (PFFF) and Zircaloy Fabrication Facility (ZFF) is in progress at the Nuclear Fuel Complex, Kota (NFC-K). AERB continued the Safety review of various submissions related to the project.

Safety Surveillance of Operating Nuclear Power Plants (NPPs) and Research Reactors (RRs)

AERB continued regulatory supervision of 22 operating NPPs in India. The radiation exposure to the occupational workers in these plants were below the prescribed limits. The radioactivity releases from all the NPPs were below 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.

The station's submissions were extensively reviewed in multi-tier systems as per the established mechanism in AERB. During 2021, 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 Authorization for radioactive waste disposal/transfer under GSR-125 for RAPS-5&6, KKNPP-1&2 and MAPS-1&2. AERB had also renewed the Licence for operation of Kalpakkam Mini reactor (KAMINI) under the Atomic Energy Act, 1962 (and rules framed thereunder).

Technology development of Containment Filtered Venting System (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 is in advance stage at MAPS-1&2, TAPS-3&4, NAPS-1&2 and KAPS-1&2.

Safety Surveillance of Operating Nuclear Fuel Cycle Facilities and other related Industrial Facilities

AERB continued to review the safety aspects of operating Nuclear Fuel Cycle facilities under its preview.

During the year, AERB renewed the licences for operation of Banduhurang mine, Turamdih mill, Rare Earth Extraction Plant (REEP) at IREL (India) Ltd., OSCOM, Zirconium Complex-Pazhayakayal, HWP-Baroda, Technology Demonstration Plant (TDP), Chembur and Electronics Corporation of India Ltd (ECIL)-Tirupathi. AERB extended the consent for trial operation of Tummalapalle mill and consent for construction of tailings pond & dam at Tummalapalle mill.

The details on Safety Surveillance of Nuclear Power Projects, Operating Plants, Research Reactors and Nuclear Fuel Cycle Facilities and other related Industrial Facilities are given in Chapter-1.

Safety Surveillance of Radiation Facilities (RF)

During 2021, AERB issued 16,230 licences (licence, authorisation and registration) for operation of various RFs, following the graded approach, in addition to 3,838 permissions for procurement of radioactive sources (imported and indigenous) and 11,995 permissions for procurement of diagnostic X-ray equipment. During the year 3,525 certified personnel obtained Radiation Safety Officer (RSO) approval. Based on the review of results of the pilot study carried out at Tata Memorial Hospital, Mumbai (TMH) for assessing the radiological safety aspects of Lu-177 therapy on outpatient basis, AERB approved the proposal for 'Usage of Lu-177 labelled Radio pharmaceuticals for therapy purpose' on outpatient basis.

The details of safety surveillance of radiation facilities during this period are given in Chapter-2.

Regulatory Inspection (RI) of Nuclear and Radiation Facilities

The regulatory inspection programme continued to face challenges during 2021 due to the COVID-19 lockdowns, which imposed travel restrictions. An alternate method of Remote Regulatory Inspections for enhancing the regulatory oversight, which was developed in 2020 was continued to be relied upon during 2021 also. This involves self-assessment of the activity/facility by the licensee based on checklists developed by AERB. Subsequently, the reports on these self-assessments are reviewed in AERB along with the evidences, which included additional records /documentation, photographs or videos and video interaction(s) with the personnel of the facilities.

AERB has posted onsite observers known as Site Observers Teams (SOT) at four NPP sites [Rawatbhata, Kalpakkam, Kakrapar and Kudankulam]. These SOTs observe activities at the operating as well as the under construction plants at the respective sites and submit reports to AERB Headquarter (HQ) on daily basis, which provides independent on-ground inputs for safety review and RIs. This has led to establishment of continuous regulatory presence at these sites, covering twelve operating, two under commissioning, and five under construction NPPs.

During the year, a total of 96 regulatory inspections of nuclear power projects, operating NPPs and fuel cycle facilities under, were carried out, covering safety (nuclear, radiological & industrial) and security aspects. Physical inspections were carried out for RAPS site (covering -1 to 6 units) and RAPCOFF for reviewing the radiological safety aspects. Apart from this, total 758 radiation facilities were also inspected. A special RI of KAPP-3&4 was

carried out to check the aspects related to high temperature issue in RB areas of KAPP-3 and the related modifications in KAPP-3&4.

The details of regulatory inspection of nuclear and radiation facilities during this period are given in Chapter-3.

A Glimpse of Remote Regulatory Inspection Centre at Head Quarter, AERB, Mumbai

Enforcement Actions in Nuclear and Radiation Facilities

AERB suspended Licence for operation of a Radiography Institution for one year owing to violation of safety requirements and withdrawn the approval for RSO and radiographer responsible, for indulging in unsafe industrial radiography operations.

The details of enforcement actions in nuclear and radiation facilities during this period are given in Chapter-1 and 2 respectively.

Emergency Preparedness

During the year AERB continued to monitor the status of emergency preparedness at the nuclear facilities. The NPPs continued to carry out Plant and Site Emergency Exercises. Annual site emergency exercises were conducted at seven NPP sites. AERB officials could not be physically present as observer in the emergency exercises (since March 2020) due to travel restriction due to COVID. However, exercises were being reviewed based on the reports submitted by the facilities subsequent to completion of the exercise. The Off-Site Emergency Exercise (OSEE) framework has been strengthened through conduct of different types of exercises, viz. Table-Top (TT) exercise and Integrated Command Control and Response (ICCR) OSEE.

During 2021, ICCR OSEEs were conducted at four NPP sites, viz. Tarapur, Narora, Kakrapar and Kudankulam.

On-site Emergency Support Centre (OESC) Facilities, which are capable of remaining functional even under extreme situations, are proposed at all the NPP sites, based on the safety review undertaken after the nuclear accident at the Fukushima Daiichi NPP in March 2011. After regulatory approvals, construction of the OESCs at Tarapur, Maharashtra site and Kakrapar, Gujarat site is in progress.

The Status of Environmental Safety and Occupational Exposures and Emergency Preparedness of the Nuclear Facilities are given in Chapter 4 and Chapter 5 respectively.

Regulatory Safety Document Development

As part of the regulatory framework, two very important Safety Directives, one regarding the definition of 'Radioactive Substance' and the other regarding 'Exemption of Radiation Generating Equipment' were issued in 2021. These Directives will play an important role in deciding the scope and domain of regulatory oversight. During the year, two REGDOCs viz. Safety Guide on 'Regulatory Control of Radioactive Discharges to the Environment and Disposal of Solid Waste', and Safety Manual on 'Methodology for Radiological Impact Assessment of Nuclear Power Plants under Postulated Accident

Conditions', were published. These documents are available on AERB's website. AERB is currently working on the development/revision of about 50 regulatory documents. As part of Indian contribution to the safety standards programme of IAEA, AERB reviewed and provided comments on a number of draft Safety Standards of IAEA.

The Status of Regulatory Safety Documents is given in Chapter 6.

Safety Analysis, Research and Development

AERB continued the safety studies in the areas of severe accidents, thermal-hydraulics safety, reactor physics, probabilistic safety assessment, radiological safety assessment and environmental and experimental studies. In addition, several important developmental studies were completed during the year 2021.

At SRI, Kalpakkam, Computational Fluid Dynamics (CFD) and Computational Solid Mechanics (CSM) coupling methodology was developed in ANSYS Workbench for estimating the associated deflection of fuel bundle due to local flow characteristics arising with flow (turbulence) induced vibration inside the coolant channel for a typical PHWR. CFD studies were taken up to investigate the effect of baffles around the calandria vessel on heat transfer characteristics during severe accident scenarios in PHWRs. Core Melt Retention Facility (COMREF) is established in SRI Engineering Hall to investigate the in-vessel retention capability of calandria vessel during postulated severe accident conditions.

A one-dimensional two-phase (Homogeneous Equilibrium Model) thermal hydraulic computer code, NuPAC (Nuclear Plant Analyzer Code) for transient analysis of water and sodium system was developed using PYTHON 3.6. A computer code for simulating passive containment cooling system (PCCS) based on natural circulation concept was developed, upgraded and integrated with in-house containment thermal hydraulic code 'THYCON'. Development of an integrated source term estimation code PRABHAVNI is ongoing at BARC. AERB has been contributing in this code development work. A new feature was added to the AERB Source Term Estimation Tool (ASTET).

AERB continued to promote and fund research projects on nuclear and radiation safety, and industrial safety at academic institutions under the Safety Research Programme. Two new projects were approved and five on-going projects were renewed.

The details of various activities of Safety analyses and research are presented in Chapter-7.

Stakeholders Engagement & Public Outreach Activities

During the COVID-19 pandemic, AERB reached out to public and its various stakeholders through the virtual platforms. To commemorate the 75th year of India's independence, our country is celebrating the 'Azadi Ka Amrit Mahotsav'. AERB has joined the year-long celebrations and conducted various awareness and scientific events and competitions. Awareness cum competition programme were conducted at a government school at Amarut village, Gaya, Bihar, and RM School and Oriental College, Imphal. AERB also hosted 5th National Conference on Regulatory Interface (NCRI-2021) in virtual mode, on the theme of 'Safety Regulation for Safety'. AERB also conducted webinars through the AERB YouTube channel for radiation workers/radiation professionals on varied topical issues for Police Personnel of Gujarat Police, DAE Safety & Occupational Health Professionals Meet and Operating Experience(OE) feedback sharing webinar series.

Release of Booklet on Occupational Injury and Fire Statistics of DAE Units -2020 by Dignitaries

AERB has identified 29 safety significant events occurred in the past in Indian NPPs for discussions and organized a series of webinars on these events from July 2021 to February 2022. So far, 11 webinars have been conducted in the presence of 350 officials from the participating organizations i.e. NPCIL-HQ, BHAVINI, NPP/projects, HWB, BARC, IGCAR and AERB.

AERB conducted an on-line webinar on 'Societal Benefits of Radiation Technology and Safety Aspects' for institutions of higher education, medical institutes, hospitals and professional associations located in and around Chandigarh.

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

Apart from the above mentioned activities, AERB provided timely responses to the queries posted by the members of public.

The details of AERB initiatives for engaging with stakeholders and public are presented in Chapter- 8 and 9.

Signing of the Bilateral Arrangement between AERB and ASN, Shri G. Nageswara Rao, Chairman, AERB and Mr. Bernard Doroszczuk, Chairman, ASN

International Cooperation

India is signatory to several international conventions related to nuclear safety and security. AERB actively participates and contributes in the multi-lateral international activities organized by International Atomic Energy Agency (IAEA) and Nuclear Energy Agency (NEA). The Bilateral Arrangement between the Nuclear Safety Authority (ASN) of France and Atomic Energy Regulatory Board (AERB) for the exchange of technical information and cooperation in the regulation of nuclear safety and radiation protection was renewed on September 21, 2021.

Chairman, AERB participated in the 65th General Conference of International Atomic Energy Agency (IAEA) held during September 20-24, 2021 at Vienna, Austria as a Member of Indian delegation led by Dr. K.N. Vyas, Chairman, Atomic Energy Commission. On September 23, 2021, Chairman, AERB attended the Senior Safety and Security Regulators' Meeting. Chairman, AERB also participated in bilateral meetings with ASN (nuclear regulatory body of France), USNRC (nuclear regulatory body of USA) and CNSC (nuclear regulatory body of Canada) arranged on the side-lines of the IAEA General Conference.

AERB's contribution at various international fora are presented in detail in Chapter-10.

Human Resource Development and Infrastructure

AERB's manpower is being augmented at various levels and through various channels in view of the expanding nuclear power programme and increasing number of radiation facilities in the country. This is being done through fresh recruitments, transfer of experienced personnel from the operating plants and R&D institutes like BARC and IGCAR and induction of Graduate Trainees from Orientation Course for Engineering Graduates and Science Postgraduates (OCES) of DAE Units as well as induction of postgraduates through AERB Graduate Fellowship Scheme (AGFS) from IIT Bombay and IIT Madras. The total sanctioned strength in AERB is 468. However, in-position strength as on December 31, 2021 is 350 comprising of 304 Scientific & Technical and 46 Administrative / Accounts / Auxiliary staff.

AERB conducted two refresher training courses on 'Containment Safety' (28 lectures) and 'Accelerators and their Safety' (10 lectures). In addition to this, nine Colloquium lectures and one Invited talk covering various topics related to nuclear and radiation safety were also arranged.

In pursuit of excellence while performing the regulatory functions by AERB employees, a Programme of Technical Excellence has been taken up at AERB. Technical Excellence Teams (TETs) comprising young officers were formed in AERB to develop resource materials in the expert area of the participants with the aim of knowledge enhancement and capturing the tacit knowledge. The participant officers took extra initiatives in creating, sharing and utilizing knowledge through collective efforts.

Accordingly, 77 projects have been identified and the presentations/resource materials on 39 topics have been completed during the year.

The details on human resources development and infrastructure and staff welfare activities are presented in Chapter-11.

Official Language Implementation

AERB conducted various programme as a part of implementation of official language 'Hindi', in official work. DAE incentive scheme for working in Hindi has been introduced and employees are actively participating in the scheme. During the year 2021, total 16,637 letters were sent in bilingual form. As part of AERB's sustained initiatives to promote safety awareness among its stakeholders, a webinar was organised on March 23, 2021 in Hindi on 'Safe Work Practices and Emergency Preparedness in Industrial Radiography'. About 100 participants from various industrial radiography units from all over the country participated in the programme.

The details on Official Language Implementation are presented in Chapter-12.

Shri G. Nageswara Rao, Chairman, AERB addressing the Hindi Day Celebration through Video Conferencing

Finance

AERB receives funds from the Government of India (GoI) for meeting all its expenditures, both capital and revenue. Central Government allocates the budget under separate head of accounts for AERB. Annual expenditure during the year 2021 was Rs.91.06 crores.

The details on Finance is presented in Chapter-13.

Conclusion

In year 2021, AERB continued the regulatory activities and safety monitoring through reviews of periodic reports on safety status of NPPs, event reports, Licence applications and through SOTs deputed at NPP sites & periodic regulatory inspections. Communication was maintained with NPP authorities to obtain safety status of NPPs on regular basis. AERB e-platform (e-LORA) is being used for issuing various consents for radiation facilities during the year. There was no disruption in the regulatory oversight by AERB due to COVID-19 pandemic this year.

CHAPTER 1

SAFETY SURVEILLANCE OF NUCLEAR FACILITIES

CHAPTER 1 - SAFETY SURVEILLANCE OF NUCLEAR FACILITIES

1.1 SAFETY REVIEW MECHANISM OF NUCLEAR FACILITIES

Nuclear 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. These licensees have a system of independent review and scrutiny of safety as an integral part of the management control. Atomic Energy Regulatory Board (AERB), the national regulatory body of India, oversees the safety and has been mandated to frame safety policies, lay down safety standards and requirements. AERB has power to monitor & enforce safety and regulatory provisions of the Atomic Energy Act, 1962 and the rules thereunder, in nuclear and radiation installations and practices. AERB has established a regulatory framework, which involves stipulating the safety requirements, issuance of regulatory consents after safety review, verification of compliance through safety reviews and inspections during various stages viz. siting, construction, commissioning, operation etc.

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

Siting

To ensure that the chosen site meets Site Evaluation Criteria and is suitable for the proposed type and capacity of plant from environmental considerations.

Construction

To ensure that the proposed plant design meet regulatory requirements, and the proposed construction meets quality requirements.

Commissioning

To ensure that the commissioning programme and procedures meet regulatory requirements; performance of the plant is as per design intent; results of commissioning tests confirm adequacy of the plant design for operation; and safety analysis for as-built facility has been carried out.

Operation

To ensure that plant operational limits & conditions meet regulatory requirements; adequate level of safety is maintained by proper operational & maintenance procedures & administrative control; organisational structure, training & qualification of operating personnel meet the requirements and conditions for renewal of consent as prescribed by AERB.

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

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

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

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

Review of Security Aspects

AERB has been also been entrusted with the responsibility of review and assessment of security aspects (having impact on safety) for different types of nuclear facilities in India. AERB has issued various regulatory documents specifying nuclear security and computer security requirements. Depending on the project stage, security aspects are reviewed against relevant regulatory requirements. Multi-tier approach is adopted for review of security aspects also.

The safety status of the nuclear facilities, significant events and enforcement actions during the year 2021 are covered in the following sections.

1.2 NUCLEAR POWER PROJECTS & FUEL CYCLE FACILITIES UNDER CONSTRUCTION

AERB has an established system for safety review of nuclear power projects and fuel cycle facilities that are under construction.

Review of Nuclear Power Projects under construction/commissioning were efficiently managed by AERB even during COVID-19 pandemic. During this period, utility submissions were communicated to reviewers through e-mail and review observations were sought. Online meetings were conducted through video-conferencing to deliberate and finalise the safety review observations.

During lockdown conditions, Nuclear Power Projects and Fuel Cycle Facilities under construction/commissioning were requested to provide the status of preservation aspects of Structures, Systems and Components (SSCs), Industrial and Fire Safety (I&FS), etc. Reports submitted by sites are noted for measures instituted for preservation, protection of SSCs, other equipment and I&FS aspects.

During year 2021, the status of various nuclear power projects and fuel cycle facilities under siting, construction and commissioning reviewed by AERB are presented in Table 1.1 and Table 1.2 respectively.

Table 1.1: Status of Nuclear Power Projects

Project Stage	Project	District/State	Utility/ Licensee/ Applicant	Type	Review Status
Site Evaluation	Mahi Banswara Rajasthan Atomic Power Project (MBRAPP)-1-4, Banswara	Banswara/ Rajasthan	NPCIL	700 MWe PHWRs each, of indigenous design	Site Evaluation is in progress. Adequacy check of Siting application was carried out. Applicant has been asked to submit additional information needed in specific areas towards admittance of application.
Construction	Kudankulam Nuclear Power Project (KKNPP)-3&4 Kudankulam	Tirunelveli/ Tamilnadu	NPCIL	1000 MWe VVER (Light Water Reactor) each, of Russian Design	Consent for First Pour of Concrete (FPC) for KKNPP-3&4 was issued in June, 2017. Review of application for Major Equipment erection (MEE) for KKNPP-3&4 and its supporting submissions is in progress. Adequacy check of MEE application was carried out. Review of application and its supporting documents is nearing completion.
	KKNPP-5&6, Kudankulam	Tirunelveli/ Tamilnadu	NPCIL	1000 MWe VVER (Light Water Reactor) each, of Russian Design	Consent for First Pour of Concrete (FPC) for KKNPP-5&6 was issued on May 12, 2021 with certain stipulations. Review is in progress for submissions received w.r.t stipulations identified in FPC consent.
	Gorakhpur Haryana Anu Vidyut Pariyojana (GHAVP)-1&2, Gorakhpur	Fatehabad/ Haryana	NPCIL	700 MWe PHWRs each, of indigenous design	Consent for First Pour of Concrete (FPC) for GHAVP-1&2 was issued on November 18, 2020. During review of the submissions certain anomalies were noted related to the construction quality of critical structures. Applicant has been asked to re-examine the issue and respond to the queries raised.

Project Stage	Project	District/State	Utility/ Licensee/ Applicant	Type	Review Status
	RAPP-7&8, Rawatbhata	Chittorgarh/ Rajasthan	NPCIL	700 MWe PHWRs each, of indigenous design	Consent for major Equipment Erection (last stage of construction consent) was issued in March 2015. Pre-commissioning activities are in progress at site.
	Kaiga NPP-5&6, Karwar	Karwar/ Karnataka	NPCIL	700 MWe PHWRs each, of indigenous design	Consent for Siting of KAIGA-5&6 was issued on November 18, 2020. Review of Supporting documents as a part of application for Excavation Consent are in advanced stage of review. Responses to the review observations are awaited from the applicant.
Commissioning	PFBR, Kalpakkam	Kancheepuram/ Tamilnadu	Bhartiya Vidyut Nigam (BHAVINI)	500 MWe prototype Fast Breeder reactor of indigenous design	Review of pre-commissioning and Phase-A commissioning activities is in progress.
	KAPP-3&4, Kakrapar	Tapi, Gujarat	NPCIL	700 MWe PHWRs each, of indigenous design	Most of the Phase-C commissioning tests up to 50%FP have been completed, and reviewed in AERB. Validity of permission for Phase-C commissioning of KAPS-3 was extended till December 31, 2022 based on the reviews. Owing to certain observations during Phase-C commissioning of KAPP-3, certain design modifications are proposed in critical structure. After satisfactory completion of this activity, commissi-oning of KAPP-3 will progress further.

Table 1.2: Status of Fuel Cycle Facilities (Under Siting, Construction and Commissioning)

Project Stage	Project	District/State	Utility/ Licensee/ Applicant	Project Details	Remarks
Siting	Additional Away From Reactor Spent Fuel Storage Facility for RAPS (AAFR)	Chittorgarh/ Rajasthan	NPCIL	Additional Away From Reactor (AAFR) Spent Fuel Storage Facility at Rawatbhata, Rajasthan Site	Review of Siting application for AAFR-RAPS is under progress. Supporting submissions as part of the Siting application have been reviewed. Responses to review observations and Revised submissions based on review are awaited from applicant.
Construction	Away From Reactor Spent Fuel Storage Facility at KKNPP-1&2 (AFR)	Tirunelveli/ Tamil Nadu	NPCIL	Away From Reactor Spent Fuel Storage Facility for storing spent nuclear fuel at KKNPP-1&2 (AFR)	Siting Consent for Away From Reactor (AFR) Spent Fuel Storage Facility at KKNPP-1&2 was issued on May 21, 2021 subject to compliance to certain stipulations.
	Away From Reactor Spent Fuel Storage Facility for KKNPP-3&4 (AFR)	Tirunelveli/ Tamil Nadu	NPCIL	Away From Reactor Spent Fuel Storage Facility for storing spent nuclear fuel of KKNPP-3&4 (AFR)	Siting Consent for Away From Reactor (AFR) Spent Fuel Storage Facility for KKNPP-3&4 was issued on August 23, 2021 subject to compliance to certain stipulations. Review of supporting documents for application for Construction of AFR for KKNPP-3&4 is in progress. Certain clarifications are awaited from applicant.
	Fast Reactor Fuel Reprocessing Facility (FRFCF), Kalpakkam	Kancheepuram/ Tamil Nadu	IGCAR	Integrated facility for recycling spent fuel from PFBR. The project includes fuel fabrication & assembly, reprocessing and waste management facilities	Permission for resumption of construction activities involving earthmoving was given on November 8, 2018.
	PHWR Fuel Fabrication Facility and Zircaloy Fabrication Facility, Rawatbhata	Chittorgarh/ Rajasthan	Nuclear Fuel Complex, Kota	Fabrication Facility for PHWR Fuel and Zircaloy components	Construction consent was issued in February, 2018.
Construction & Commissioning	Demonstration Fast Reactor Fuel Reprocessing Plant (DFRP), Kalpakkam	Kancheepuram/ Tamil Nadu	IGCAR	Reprocessing Facility for Spent Fuel From Fast Breeder Test Reactor (FBTR).	Validity for permission for continuation of commissioning activity of acid-TBP run for DFRP was extended till December 31, 2021.

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 PHWR, PFBR & LWR)	3
Project Design Safety Committee – Fast Breeder Reactor (PDSC-FBR)	3
Project Design Safety Committee – Light Water Reactor (PDSC-LWR)	6
Project Design Safety Committee – Pressurized Heavy Water Reactor (PDSC-PHWR)	11
Civil Engineering Safety Committee (CESC)	10
Safety Evaluation Committee (SEC)	3
Total	**36**

**Apart from these meetings, many In-house Group meetings organized for safety review*

1.2.1 NPPs Under Construction: Review Status

Safety review activities related to the Nuclear Power Projects (refer Table 1.1) continued during the year 2021.

(a) Light Water Reactor Based NPPs

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

KKNPP Unit-3&4 plant design is a repeat design of KKNPP Unit-1&2, which was extensively reviewed in AERB. Review process for Unit-3&4 is optimized to review the design differences impacting safety and compliance to AERB Safety Code on 'Design of Light Water Reactors based Nuclear Power Plants' (AERB/NPP-LWR/SC/D). AERB had issued clearance for First Pour of Concrete (FPC) on June 23, 2017 with certain stipulations. Presently, civil construction work is in progress at KKNPP-3&4 and the stipulations made during FPC consent are being followed up. Erection of core catcher, for which permission was issued earlier, was successfully completed along with its support structures.

Currently, safety review of Application for Erection of Major Equipment (MEE) and its supporting documents including Preliminary Safety Analysis Reports (PSARs) Rev.1 of various plant systems is nearing completion.

Overall View of KKNPP-3&4

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

NPCIL submitted an application to AERB on April 4, 2019 for the Clearance for KKNPP-5&6 for First Pour of Concrete (FPC). The application and its supporting submissions including Preliminary Safety Analyses Reports were reviewed. Review process for Unit-5&6 is optimized to review of design differences impacting safety w.r.t. KKNPP-3&4 and

compliance to AERB Safety Code on 'Design of Light Water Reactors based Nuclear Power Plants'. Board of AERB approved issuance of Consent for First Pour of Concrete (FPC) for KKNPP-5&6 and the Consent was issued on May 12, 2021.

(b) Fast Breeder Reactor Based NPP

(i) Prototype Fast Breeder Reactor (PFBR)

Prototype Fast Breeder Reactor (PFBR) project is currently in commissioning stage. Safety review of Phase-A commissioning activities is in progress. Main Vessel has been cooled down and both loops of Secondary Sodium Main Circuits (SSMC) are in drained state to allow manual entry into the hot pool for investigation and rectification of certain deficiencies observed during commissioning. Based on the root cause analysis conducted, BHAVINI has proposed certain modifications on Sub-Assemblies (SAs). The adequacy of investigations towards establishing root cause for high lifting load and scoring of dummy SAs and proposed modifications is under review.

Inert conditions are being maintained in drained SSMC (Secondary Sodium Main Circuit) with the help of Argon cover gas. Sodium in all storage tanks, except Safety Grade Decay Heat Removal (SGDHR) storage tanks, is in frozen condition. Sodium in SGDHR Storage tanks is maintained in molten condition for the commissioning of SGDHR sodium purification circuit.

Review & assessment of commissioning procedures and reports pertaining to fuel handling system are in progress. Emergency Action Levels (EALs) forming part of the Plant emergency preparedness and response manual were reviewed. Licensing programme for operation & fuel handing personnel for PFBR and senior management certification document were reviewed and approved and authorisation of operating personnel for the Level I, II & III positions was carried out.

Based on review of Application for authorization of Transfer of Category-I Liquid waste to common waste management facility (CWMF) Kalpakkam, permission to transfer the generated Category-I liquid waste to CWMF for disposal as a temporary measure was issued on November 15, 2021.

Prototype Fast Breeder Reactor (PFBR)

(c) Pressurized Heavy Water Rectors (PHWR) Based NPPs

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

Safety review for the twin units of 700 MWe PHWRs at Kakrapar, Gujarat (KAPP-3&4) is in progress. Review and assessment of the submissions include Commissioning procedures and reports, Technical Specifications for Operation, Environmental Qualification (EQ) reports, Independent Verification and Validation (IV&V) reports etc. Design safety related aspects common for 700 MWe PHWR projects were reviewed as part of KAPP-3 safety review.

NPCIL application seeking Authorization for Phase-C commissioning of KAPP-3 (i.e. raising Reactor power in stages) was reviewed and Permission with Regulatory Hold Points (RHPs) was issued on November 02, 2020. After review of NPCIL submissions towards clearing RHPs, Permission for Phase C-1 (i.e. raising Nuclear Steam by increasing Reactor Power up to 50% FP of KAPP-3) was issued on November 12, 2020. KAPP-3 Turbine Generator was synchronized to the grid on January 10, 2021.

KAPP-3 is currently under Phase-C commissioning (within the permission to operate the Reactor up to 50% FP) stage. Most of the Phase-C commissioning tests up to 50% FP have been completed, and reviewed in AERB. Validity of permission for Phase-C commissioning of KAPP-3 has been extended till December 31, 2022 based on the reviews of Commissioning test results.

During power raise and subsequent PHT system heat up during Phase-C commissioning of KAPP-3, high area temperatures, beyond that considered in the

design, were observed near the structural steel beam grid floor (EL-11500) above fuelling machine vaults. To address the issue of observed high temperature for normal operation of the plant, as well as from all other possible thermal loading scenarios, NPCIL re-assessed the structural steel floor and proposed certain modifications in the already constructed and loaded structural steel members. In addition, certain modifications in the ventilation system are also proposed. NPCIL proposals along with the assessments were reviewed. Based on safety review, AERB permitted NPCIL to implement the identified modifications. After implementation of modifications and monitoring of performance at high temperature, resumption of commissioning activities will be considered.

KAPP-4 is in advanced stage of equipment erection and pre-commissioning activities are in progress. Installation of internal core components of reactivity devices and erection of feeders has been completed. Activities related to installation of Main PHT piping and its hydro test, and moderator piping are in progress.

KAPP-3&4 Main Plant Area

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

Safety review for the twin units of 700 MWe PHWRs at Rawatbhata, Rajasthan (RAPP-7&8) is in progress. The design of RAPP-7&8 are similar to KAPP-3&4. Design safety related aspects common for 700 MWe PHWR projects were reviewed as part of along with KAPP-3 safety review. In RAPP-7&8, civil construction and erection of equipment/components and pre-commissioning activities are in progress. RAPP-7&8 has been asked to update the commissioning procedures based on the commissioning review and experience of KAPP 3&4.

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

Excavation Consent (EC) for GHAVP-1&2 was issued on January 17, 2018. At GHAVP-1&2, Ground improvement by replacing soil by compacted soil-cement has been undertaken to address the potential liquefaction concerns. Excavation for main plant area of GHAVP-1&2 has been completed. Piling activities for the foundation and confirmatory pile tests in the Nuclear Building area have also been completed. Excavation activity in other plant areas is in progress. Considering the characteristics of founding strata vis-a-vis configuration and layout of structures, combined pile-raft type of foundation system is proposed for certain safety related structures and raft foundation for others.

NPCIL application for First Pour of Concrete (FPC) of GHAVP-1&2 has been reviewed at AERB. Consent for FPC of GHAVP-1&2 with Regulatory Hold Points was issued after approval by Board of AERB on November 18, 2020. Towards ascertaining the considered behavior and capacities of foundation piles, NPCIL undertook confirmatory pile tests in NB area, which were witnessed remotely by AERB. Based on the review of the results of confirmatory pile tests, the behavior of pile and its capacity to be considered in final analysis was accepted by AERB.

In parallel, construction of foundation piles in NB area has been completed. Towards ensuring the integrity of foundation piles, pile integrity tests and Cross-hole Sonic Logging (CSL) tests were conducted on piles of NB#1. Actions to address AERB's review observations on the reports of CSL tests of NB#1, are currently under review.

Applications for permission to start construction of Safety Related Pump House (SRPH) & Fire Water Pump House (FWPH) of GHAVP-1&2 were reviewed. Permission for construction of SRPH, FWPH of GHAVP-1&2 was issued on February 2, 2021. Subsequently, based on the satisfactory review of the NPCIL submissions at AERB, Regulatory hold-points (RHPs) for Fuel Oil Storage Area (FOSA) and Ventilation Stack structures at GHAVP-1&2 were cleared and permission was issued for starting construction of these safety related structures on December 29, 2021. RHP for Safety Related Tunnels and Trenches (T&T) was also cleared with

certain stipulations. Validity period of Excavation Consent (for completion of excavation works for Induced Draft Cooling Towers, Emergency Make-up Water Pond, Fire, Industrial Safety & Health Complex, Culverts, Bridges, Roads, Hard-Stands, Turning Pads, safety related Tunnels & Trenches) of GHAVP-1&2 was extended up to March 31, 2023.

GHAVP Nuclear Building

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

NPCIL has proposed to construct two 700 MWe PHWR based Nuclear Power Plants at Kaiga site where four 220 MWe PHWR type reactors are already in operation. The proposed NPPs at KAIGA-5&6 are similar to 700 MWe PHWR projects at GHAVP-1&2, except certain site specific changes.

Consent for Siting of KAIGA-5&6 was issued after approval by the Board of AERB on November 18, 2020. NPCIL has submitted the application for Excavation Consent for KAIGA-5&6 which is under review by AERB.

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

NPCIL has proposed to construct four 700 MWe PHWR based Nuclear Power Plants at Mahi Banswara, Rajasthan The proposed NPPs at MBRAPP are similar to 700 MWe PHWR projects at GHAVP-1&2, except certain site specific changes.

Application for Siting Consent of Mahi Banswara Rajasthan Atomic Power Project Units 1 to 4 (MBRAPP 1 to 4) along with certain supporting documents has been submitted. Adequacy review of the application and supporting documents by AERB has indicated additional information is needed before admittance of application by AERB.

(vi) Chutka Madhya Pradesh Atomic Power Project (CMPAPP)-1&2

NPCIL submitted application for siting consent of 2 x 700 MWe PHWR at Chutka Village of Mandla District in Madhya Pradesh (CMPAPP) during April 2016. In absence of identified submissions, NPCIL siting application was considered as returned to the applicant and the same was communicated to NPCIL.

1.2.2 Fuel Cycle Facilities Under Construction

Safety review of Fuel Cycle Facilities under construction continued during the year.

(i) Isotope Production and Processing Facility (IPPF)

A 'Letter of Intent' was submitted by NPCIL in October 2021 towards establishing an Isotope Production and Processing Facility for production of radioisotopes for pharmaceutical use through a Public Private Partnership (PPP) model. The IPPF facility consists of a Radioisotope Production Reactor (RPR) of 60 MWt and Radioisotope Processing Facility (RPF). The IPPF is proposed to be established at Kakrapar, Gujarat Site. NPCIL had requested for a preliminary review by AERB with regard to acceptability of proposed exclusion zone before taking up activities related to Siting consent and other statutory clearances.

The justification note for proposed exclusion zone, an explanatory note with conceptual design of reactor, site layout, preliminary Radiological Impact Assessment (RIA) for normal operation for RPR & RPF and preliminary RIA for accident conditions for RPR along with the letter of intent were reviewed. Based on the preliminary review, it is assessed that the proposed exclusion zone boundary for IPPF facility may be acceptable, subject to satisfying the criteria of AERB Safety Code AERB/NF/SC/S Rev.1, at exclusion zone boundary and compliance to the recommendations brought out by AERB during review of Letter of Intent. The detailed review of aspects related to hazard category of the facility, RIA etc. will be taken up at the siting stage, after receiving the formal application.

(ii) Demonstration Fast Reactor Fuel Processing Plant (DFRP)

DFRP is being set up at Kalpakkam for reprocessing of the spent fuel from Fast Breeder Test Reactor (FBTR) on regular basis and demonstration of reprocessing process of the PFBR spent fuel. Fabrication and erection work is in progress for head-end facility. Based on review the validity for permission for continuation of commissioning activity of acid-TBP run for DFRP was extended till December 31, 2021. Commissioning of DFRP is in progress. Commissioning Test Reports are being reviewed in AERB and the review observations are communicated to the site. In Process Plant Facility, commissioning activities of acid-Tri-butyl phosphate (TBP) run are completed and commissioning reports are awaited.

(iii) 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 each of 250 TPA PFFF and 65 TPA ZFF will be set up and 100 TPA ZFF will be added in second phase in near future.

AERB issued siting consent for NFC-K on May 28, 2014. Construction Consent to NFC-Kota was granted on Feb 05, 2018 with certain stipulations. Presently, construction of plant buildings of ZFF and PFFF is in progress. Safety review of various submissions is in progress.

(iv) Away From Reactor Spent Fuel Storage Facilities

KKNPP-1&2 (AFR): NPCIL submitted Application for Siting Consent for Away From Reactor (AFR) Spent Fuel Storage Facility at KKNPP-1&2 along with its supporting documents. Based on the review, AERB issued Siting Consent for AFR Spent Fuel Storage Facility at KKNPP-1&2 on May 21, 2021 subject to compliance to certain stipulations. Review of NPCIL submissions with respect to Application for Excavation clearance of AFR at KKNPP-1&2 is in progress.

KKNPP-3&4 (AFR): NPCIL submitted Application for Siting Consent for AFR Spent Fuel Storage Facility for KKNPP-3&4 along with its supporting documents. Based on the review, AERB issued Siting Consent for AFR Spent Fuel Storage Facility for KKNPP-3&4 on August 23, 2021 subject to compliance to certain stipulations. Review of NPCIL submissions with respect to Application for Construction clearance AFR for KKNPP-3&4 is in progress.

RAPS (AAFR): Application for Siting consent for the Additional Away From Reactor (AAFR) Spent Fuel Storage Facility at RAPS site along with its supporting documents (viz. Site Evaluation Report, Preliminary safety assessment report on design basis information) is under review.

1.3 OPERATING NUCLEAR POWER PLANTS AND RESEARCH REACTORS

1.3.1 Operational Safety Review

AERB carries out safety review and surveillance of operating NPPs & research reactors following multi-tier review process. Exhaustive review takes place during review of application for renewal of Licence for operation and resolution of other safety issues that would emanate during plant operation. Currently there are 22 operating NPPs in the country. The details of these NPPs indicating their capacity, commencement of operation and validity of current operating Licence is given in Table 1.4 below.

Table 1.4: List of Operating NPPs

Operating NPPs	Site/District/State	Unit	Type	Gross Capacity (MWe)	Commencement of Operation	Validity of Licence
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/ Chithaurgarh/ Rajasthan	RAPS-1#	PHWR	100	December 1973	August 2024
		RAPS-2		200	April 1981	
		RAPS-3		220	June 2000	October 2022
		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	
Narora Atomic Power Station	Narora/ Bulandshahar/ Uttar Pradesh	NAPS-1	PHWR	220	January 1991	June 2023
		NAPS-2		220	July 1992	
Kaiga Atomic Power Station	Kaiga/Uttar Kannada/Karnataka	KGS-1	PHWR	220	November 2000	May 2022
		KGS-2		220	March 2000	
		KGS-3		220	May 2007	April 2023
		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	

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

1.3.2 Licences/Consents/Clearances/Permissions Issued

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 authorization for safe disposal/ transfer of radioactive waste under the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 (GSR-125) for next five years based on satisfactory safety review. During the year, a number of applications from the utilities were reviewed and licences for operations/clearances/permissions /authorizations were issued. Important among these are as follows:

1) Renewal of Licence for operation of TAPS-1&2 up to March 31, 2026.

2) Renewal of Licence for operation of TAPS-3&4 up to August 31, 2026.

3) Renewal of Licence for operation of KKNPP-1&2 up to July 31, 2025.

1.3.3 Safety Review of Operating Nuclear Facilities and Research Reactors

During this year, RAPS-2, 3, 4, 5 & 6, KGS-1, 2, 3 & 4, MAPS-2, NAPS-1&2, KAPS-1&2, TAPS-3&4 and KKNPP-1&2 were operational. RAPS-1 is under shut down since October 2004 and reactor core is defueled.

MAPS-1 is under shutdown since January 30, 2018 due to leak from two pressure tubes and North End Shield. Investigations towards establishment of root cause of pressure tubes & end shield leak/

degradation, rectification of end shield leak, fitness-for-service assessment of coolant channels & end shield are in progress.

TAPS-1 & TAPS-2 are also under shutdown since January 08, 2020 and July 13, 2020 respectively due to observed degradation in primary system piping weld joints during in-service inspection. Station is in process of replacement/repair of all Class-I piping vulnerable to Inter-Granular Stress Corrosion Cracking (IGSCC).

Number of meetings conducted by various Safety Committees/Standing Committees/Expert Groups during the year 2021 is given in table 1.5.

Table 1.5: Meetings of Safety Committees

Name of the Committee/Expert Group	No. of Meetings
SARCOP	11
LWR Safety Committee (TAPS-1&2 & KK-1&2)	15
PHWR Safety Committee -1 (RAPS-1&2, MAPS-1&2, NAPS & KAPS-1&2)	12
PHWR Safety Committee-2 (KGS-1&2, KGS-3&4, RAPS-3&4 & RAPS-5&6)	8
PHWR Safety Committee -3 (TAPS-3&4)	15
IGCAR Safety Committee (FBTR, CORAL, KAMINI, IFSB, RML & RCL)	1
Standing Committee on Control, Instrumentation & Computer Based Systems (SCCI & CS)	6
Expert Group on Coolant Channels (EGCC)	14
Total	**82**

1.3.4 Regulatory Oversight for Safety of Operating NPPs during COVID-19

Since the incipience of COVID-19 pandemic in India in March, 2020; NPPs have taken various measures to prevent the spread of infection. These include general awareness on preventive measures for COVID-19, maintaining social distance, wearing masks, restrictions on meetings, sterilization of work area, temperature screening of employees, no-touch entry to plant premises and arrangement of necessary medical facilities. NPPs have also undertaken measures for vaccination of their staff. In the year 2021, state-level & district level lockdowns/ restrictions were imposed in the months of April – June 2021 owing to the second wave of COVID infections. During this the operating NPPs continued to operate safely. Availability of operating manpower and other essential staff was ensured by NPPs as per the technical specifications for operation and other requirements. Supply of essential consumables/ spares required for safe operation of NPPs was also ensured. No operational or safety issues were experienced in NPPs due to COVID-19 pandemic related aspects. Necessary surveillances and maintenance activities were undertaken in a timely manner to ensure availability of safety systems. NPPs continued to report on the number of COVID-19 infections at the site to AERB on fortnightly basis.

In year 2020, AERB had earlier shared the 'Action Plans adopted by worldwide NPPs to manage risks related to COVID-19' received from IAEA with NPCIL for comparison with action plans adopted by NPPs. NPCIL had confirmed that the measures undertaken to ensure safe operation of NPPs were in line with the IAEA Action plans. In year 2021 also, NPPs have been continuing the implementation of these measures. In year 2020 due to restrictions imposed by pandemic in conducting full-fledged

command & control exercises, many NPPs had carried out table top exercises on emergency preparedness & response to assess the preparedness of responders. In year 2021, full-fledged offsite integrated command and control emergency preparedness & response exercises were carried out at Kakrapar, Rawatbhata Rajasthan (RR), Tarapur and Narora NPP sites.

In year 2021, AERB continued exercising its regulatory oversight through reviews of periodic reports on safety status of NPPs, event reports, Licence applications, etc. and safety appraisal through SOTs deputed at NPP sites & remote regulatory inspections. AERB carried out these activities through teleconferencing and video conferencing. Communication was maintained with NPP authorities to obtain safety status of NPPs on routine basis. There was no disruption in regulatory oversight of AERB due to COVID-19 pandemic.

AERB maintained international cooperation by participating in technical meetings through video conference with IAEA, NEA, etc. Updates on important issues related to NPP safety are displayed on AERB website for information to the public.

1.3.5 Safety Status of Operating NPPs and Research Reactors

(i) Tarapur Atomic Power Station (TAPS)-1&2

Licence for operation of TAPS-1&2 under Atomic Energy Act, 1962 & Factories Act, 1948 (and rules framed there under) and authorization for radioactive waste disposal/transfer under GSR-125 was valid up to March 31, 2021. Station had submitted applications for renewal of these licenses/ authorization to AERB.

These applications were reviewed by AERB following multi-tier review process. Review assessment indicated that the performance of TAPS-1&2 with respect to nuclear, radiological and industrial safety had been satisfactory. The results of In-Service Inspections (ISI) of SSCs were satisfactory except reactor recirculation piping affected by IGSCC. Station is in process of replacement/repair of all Class-I piping vulnerable to IGSCC. Radioactive effluent discharges from the station remained well below the limits specified in technical specifications for operation. Effective dose to a member of public residing at exclusion zone was well within the limit prescribed by AERB. Station possesses technical & administrative capability for safe operation of the plant. Station has a well-established program for utilization of operating experience and had implemented a number of safety modifications. Station had implemented all short- & medium-term safety upgrades identified based on review of Fukushima NPP accident. Station had committed to implement long term post Fukushima safety upgrades (establishment of OESC, implementation of DSS, etc.) in a time bound manner.

Based on the assessment of the applications, AERB renewed licences for operation of TAPS-1&2 for next five years i.e. up to March 31, 2026.

(ii) Tarapur Atomic Power Station (TAPS)-3&4

Licence for operation of TAPS-3&4 and authorization for radioactive waste disposal/transfer were valid up to August 31, 2021. TAPS-3&4 underwent Periodic Safety Review (PSR) as a pre-requisite for renewal of its operating Licence beyond August 31, 2021, under the Atomic Energy Act, 1962. Station had also submitted application for renewal of Licence for operation under the Factories Act, 1948 and authorization for radioactive waste disposal/transfer under GSR-125.

These applications were reviewed by AERB following multi-tier review process. Review assessment indicated that the performance of TAPS-3&4 with respect to nuclear, radiological and industrial safety had been satisfactory. The performance of emergency protection system, safety system, engineered safety features & containment systems were satisfactory. The results of In-Service Inspections (ISI) of SSCs were found to be satisfactory. Comprehensive ageing management programme exists at the station for System Structure Components (SSCs). 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 was well within the limit prescribed by AERB. Station possesses technical & administrative capabilities for safe operation of the plant. Station has a well-established program for utilization of operating experience and had implemented a number of safety modifications.

Station had implemented all short & medium-term

safety upgrades identified based on review of Fukushima NPP accident. Station had committed to complete the pending activities such as implementation of post Fukushima long term safety upgrades/measures (establishment of OESC, installation of CFVS, implementation of DSS, etc.), condition assessment & repair of degradation in civil structure in time bound manner.

Based on the assessment of station applications, AERB renewed licences for operation of TAPS-3&4 for next five years i.e. up to August 31, 2026.

(iii) Kudankulam Nuclear Power Plant (KKNPP)-1&2

Licence for operation of KKNPP-1&2 and authorization for radioactive waste disposal/transfer were valid up to July 31, 2020. KKNPP-1&2 underwent Periodic Safety Review (PSR) as a pre-requisite for renewal of its operating Licence beyond July 31, 2020 under the Atomic Energy Act, 1962. Station had also submitted application for renewal of Licence for operation under the Factories Act, 1948 and authorization for radioactive waste disposal/transfer under GSR-125. Based on preliminary review, in the year 2020, AERB had extended the Licence for operation of KKNPP-1&2 and authorization for radioactive waste disposal/transfer for limited duration i.e. up to July 31, 2021.

Subsequently, station applications were reviewed by AERB following multi-tier review process. Review assessment indicated that the performance of KKNPP-1&2 with respect to nuclear, radiological and industrial safety had been satisfactory. The performance of emergency protection system, safety system, engineered safety features & containment systems were satisfactory. ISI of SSCs important to safety did not reveal any major degradation. 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 was well within the limit prescribed by AERB. Station possesses technical & administrative capabilities for safe operation of the plant. Station has a well-established program for utilization of operating experience and had implemented a number of safety modifications. Station had also given commitment for completion of pending activities such as comparison of design of KKNPP-1&2 with KKNPP 3 to 6, availability of EQ preservation manual, establishment of comprehensive ageing management program, ISI and maintenance program for civil structure, etc. in time bound manner. Based on the assessment of station applications, AERB renewed licenses for operation of KKNPP-1&2 up to July 31, 2025.

(iv) Permission for 30th Irradiation Campaign for Fast Breeder Test Reactor (FBTR), IGCAR

On completion of the 29th irradiation campaign, FBTR had submitted an application for commencement of 30th irradiation campaign at its rated power 40 MWt for the first time. The main objectives of this irradiation campaign were continuation of irradiation of sodium bonded metallic fuel pins and continuation of long-term irradiation of structural materials. In this irradiation campaign, reactor is proposed to operate at its design power level i.e. 40 MWt. In view of this, FBTR had submitted safety report for 40 MWt core configuration. Based on satisfactory review of FBTR submission following multi-tier review process, AERB had granted the permission for commencement of 30th irradiation campaign of FBTR.

1.3.6 Safety Assessment of Operating NPPs post Fukushima Accident

Safety assessments carried out post Fukushima NPP accident had indicated that Indian NPPs have inherent strength in dealing with external hazards. However, certain safety enhancements were identified for strengthening the defences against rare external events exceeding the design bases and enhancing severe accident mitigation capabilities. These actions were classified as short, medium and long term measures/safety upgrades. Implementations of short and medium term safety measures/upgrades have been already completed. The long term enhancements identified for enhancing severe accident management programme, strengthening hydrogen management provisions, provision of containment filtered venting and creation of on-site emergency support centre.

These measures may require detailed R&D efforts, analysis, detailed engineering and testing/qualification. The severe accident management guidelines for different NPP designs (PHWR, BWR

& PWR) were developed and are now in place at all the NPPs. The activities related to R&D, engineering, testing & qualification related to the rest of the long term enhancements have been completed and their on-site implementation is now in progress. The present status of long term safety upgrades/measures is as follows:

(a) Strengthening Hydrogen Management Provisions

The hydrogen management scheme in Indian PHWRs includes provision of suitable number of Passive Catalytic Recombiner Devices (PCRDs) along with provisions for homogenizing the containment atmosphere and maintenance of the inert steam atmosphere. Installation of PCRDs along with the associated instrumentation and equipment of Post-Accident Hydrogen Management System (PAHMS) is in progress in the operating NPPs. Installation of PCRDs have been completed in all PHWR units.

PCRDs installed at KAPS-1&2

(b) Provision of Containment Filtered Venting System (CFVS)

Technology development of CFVS System 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 is in advance stage at MAPS-1&2, TAPS-3&4, NAPS-1&2 and KAPS-1&2.

Scrubber Tank Installation at TAPS-3&4

CFVS construction at MAPS-1&2

(c) Creation of On-Site Emergency Support Centre (OESC)

On-site Emergency Support Centre building is proposed at all the NPP sites based on the safety review undertaken after Fukushima accident. AERB has framed requirements and guidelines for establishing On-Site Emergency Support Centres (OESCs) at all NPPs, which takes into account the NPPs at the given site and the accident scenarios. Review of civil engineering design basis for OESC buildings at all sites except Narora were completed by AERB in previous years. Based on the satisfactory review of submissions, permission for construction of OESC at Kalpakkam site and Tarapur site were granted during 2021. Activities such as geo-technical investigation, finalization of BDBE spectra & related analysis, award of tender for construction of building/construction of OESC etc. are at different stages of completion. After regulatory approvals, construction of the OESCs at Tarapur, Maharashtra site and Kakrapar, Gujarat site is in progress.

Construction of OESC at Kakrapar, Gujarat Site

1.3.7 Licensing of Operating Staff

Operating personnel of NPPs responsible for control room operation namely Shift Charge Engineer (SCE), Assistant Shift Charge Engineer (ASCE) and Control

Engineer (CE) are required to go through a rigorous licensing/relicensing process. This includes clearing checklists, written examination, walkthrough and finally qualification interviews. A candidate after successfully completing the pre-requisites of licensing procedure, appears before the licensing committee constituted by AERB for qualification interview. This committee has member(s) from AERB. On satisfactory performance, the candidate is licensed/re-licensed for the given position.

During the year 2021, total 23 meetings were held for licensing/re-licensing of operating personnel responsible for control room operations at various operating NPPs. Total of 178 candidates were licensed/relicensed. In addition to above 16 personnel for FBTR operation (Senior Shift Engineers-3, Senior Fuel Handling Engineer-1, Junior Shift Engineer -5, Control Room Assistants/Field Supervisors-7) and 2 personnel for KAMINI operation (Shift in-charge-1, Control Room Assistants/Field Supervisors-1) were also licensed/relicensed. Details of manpower licensing of NPPs are given in table below.

Table 1.6: Licensing of Operating Staff

Plants	No. of Persons Licensed				
	SCE	ASCE	ASCE (F)	CE	CE (F)
TAPS-1&2	4	5	-	4	-
TAPS-3&4	6	2	3	4	3
RAPS-1&2	3	2	-	9	1
RAPS-3&4	4	8	2	4	-
RAPS-5&6	5	5	-	5	1
MAPS-1&2	2	1	1	2	-
NAPS-1&2	3	4	2	5	-
KAPS-1&2	-	2	2	8	4
KGS-1&2	3	4	1	10	4
KGS-3&4	4	3	3	7	2
KKNPP-1&2	4	-	-	17	-
Total	**38**	**36**	**14**	**75**	**15**

1.3.8 Authorization for Safe Disposal/Transfer of Radioactive Waste

At present, the renewal of authorization for Safe Disposal/Transfer of Radioactive Wastes for DAE Facilities is integrated with the renewal of Licence for Operation under AE(RP)R-2004. A list of DAE facilities for which authorization for safe disposal/ transfer of radioactive waste were granted in the year 2021 are indicated in Table 1.7.

Table 1.7: Authorization for Safe Disposal/Transfer of Radioactive Waste for DAE Facilities under GSR-125

Type of Facility	Waste Authorization issued
TAPS-1&2	02 (includes waste authorization of AFR & AAFR of TAPS-1&2)
TAPS-3&4	01
KKNPP-1&2	01
IGCAR Facilities (RML and RCD)	02
Banduhurang Uranium Mine	01
Tummalapalle Uranium Mills (Trial Operation)	01
Turamdih Uranium Mills	01
IREL (India) Ltd., Mineral Processing Facility	01
Rare Earth Extraction Plant, IREL (India) Ltd., OSCOM	01
Technology Demonstration Plant (TDP), Chembur	01

1.4 NUCLEAR FUEL CYCLE AND OTHER RELATED INDUSTRIAL FACILITIES

1.4.1 Operational Safety Review

The nuclear fuel cycle facilities and other related industrial facilities 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 IREL (India) Ltd., Nuclear Fuel Complex (NFC), Zirconium Complex (ZC), Heavy Water Plants (HWP), Electronic Corporation of Indian Ltd. (ECIL) Atomic Minerals Directorate for Exploration and Research (AMD) and some of the facilities of Indira Gandhi Centre for Atomic Research (IGCAR). In addition to these, Beach Sand Minerals (BSM) and other facilities handling Naturally Occurring Radioactive Materials (NORM) are also regulated by AERB w.r.t. radiological safety aspects. The list of fuel cycle facilities is presented in Table 1.8.

Table 1.8: 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 Licence
Facilities Operated by UCIL					
Mines	Narwapahar	In operation	Singhbhum (E)/ Jharkhand	Underground Uranium Mine	March 31, 2023
	Turamdih	In operation	Singhbhum (E)/ Jharkhand	Underground Uranium Mine	December 31, 2023
	Bagjata	In operation	Singhbhum (E)/ Jharkhand	Underground Uranium Mine	June 30, 2025
	Mohuldih	In operation	Singhbhum (E)/ Jharkhand	Underground Uranium Mine	October 31, 2024
	Jaduguda	Shutdown	Singhbhum (E)/ Jharkhand	Underground Uranium Mine	January 31, 2023
	Bhatin	Shutdown	Singhbhum (E)/ Jharkhand	Underground Uranium Mine	April 30, 2023
	Banduhurang	In operation	Singhbhum (E)/ Jharkhand	Opencast Uranium Mine	June 30, 2026
	Tummalapalle	In operation	Y.S.R. Kadapa/ Andhra Pradesh	Underground Uranium Mine	February 28, 2023
	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	Under Trial Operation	Y.S.R. Kadapa/ Andhra Pradesh	Uranium Ore Processing	June 30, 2022
Facilities Operated by IREL (India) Ltd.					
Mines	Chavara	In operation	Kollam/Kerala	Mineral Separation	August 31, 2024
	Manavalakurichi	In operation	Kanyakumari/ Tamilnadu	Mineral Separation	August 31, 2024
	OSCOM Chatrapur	In operation	Ganjam/Odisha	Mineral Separation	August 31, 2024
Ore Processing Facilities	OSCOM, Chatrapur	In operation	Ganjam/Odisha	Monazite Processing	April 30, 2025
Others	Udyogamandal	In operation	Ernakulam/ Kerala	Rare Earths Compounds and Uranium production	November 30, 2023
Facilities Operated by NFC					
Nuclear Fuel Fabrication Facilities	NFC Hyderabad	In Operation	Hyderabad/ Telangana	Fuel Fabrication	August 31, 2022
	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 Licence
Facilities Operated by HWB					
Heavy Water Plants	HWP-Kota, Rawatbhata	In Operation	Rawatbhata/ Chittorgarh Dist./ Rajasthan	Heavy Water Production	December 31, 2025
	HWP-Manuguru	In Operation	Manuguru/ Khammam Dist./ 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
	HWP-Baroda	Heavy Water Production Suspended Diversified activities like 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, 2023
	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, 2023
	HWP-Talcher	Heavy Water Production Suspended.	Talcher/ Angul Dist./Odisha	Production of Solvents: TBP, ^{10}B Enriched B, D2EHPA, TOPO, TAPO, DNPPA and other Products viz. ^{10}B Enriched B, Boric acid	August 31, 2025
	TDP-Chembur	Main Plant is Shut down (However, different systems are being operated in closed loop for developmental activities)	Mumbai/ Maharashtra	Crude Sodium Di-Uranate	October 31, 2026

1.4.2 Licences/Consents/Clearances/Permissions Issued

AERB continued its regulatory supervision of fuel cycle facilities. AERB renews Licence for operation to these facilities under the Atomic Energy Act, 1962 (and rules framed thereunder), The Factories Act, 1948 (and rules framed there under) and authorization for safe disposal/transfer of radioactive waste under the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 (GSR-125) for next five years based on satisfactory safety review. During the year, a number of applications from these facilities were reviewed and licences for operations/clearances/permissions/authorizations were issued.

(i) Licence for operation of Banduhurang mine was renewed up to June 30, 2026.

(ii) Consent for trial operation of Tummalapalle Mill was extended up to June 30, 2022.

(iii) Licence for operation of Turamdih Mill was renewed up to February 28, 2026.

(iv) The validity of the consent for construction of tailings pond & dam at Tummalapalle Mill of UCIL was extended up to March 31, 2026.

(v) Licence for operation of Rare Earth Extraction Plant (REEP) at IREL (India) Ltd., OSCOM issued was renewed up to April 30, 2025.

(vi) Permission for setting up a separate facility for processing lean Rare Earth (RE) Chloride solution at Rare Earth Extraction Plant (REEP) at IREL (India) Ltd., OSCOM, Odisha.

(vii) Licence for operation of Zirconium Complex-Pazhayakayal under The Factories Act, 1948 was renewed up to June 30, 2026.

(viii) Extension of validity of consent for construction of pilot plant at New Uranium Oxide Fuel Plant (NUOFP), NFC, Hyderabad up to May 31, 2022.

(ix) Extension of validity of clearance for siting & construction of Magnesium Recycling Technology Development & Demonstration Facility (MRTDDF) at Zirconium Complex (ZC), Pazhayakayal.

(x) Licence for operation of HWP- Baroda under The Factories Act, 1948 was renewed up to May 31, 2026.

(xi) Licence for operation of TDP-Chembur was renewed up to October 31, 2026.

(xii) Licence for operation of ECIL-Tirupathi was renewed up to October 31, 2026.

1.4.3 Safety Review of Fuel Cycle Facilities

Number of meetings conducted by various safety committees for fuel cycle facilities and other industrial facilities during this period is given in Table 1.9.

Table 1.9: Meetings of Safety Review Committees of Fuel Cycle Facilities

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

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

(i) Uranium Corporation of India Limited (UCIL)

During the year, the uranium mines at Jaduguda, Narwapahar, Turamdih, Bagjata, Mohuldih, Banduhurang and Tummalapalle were under operation. UCIL mine at Bhatin is presently under shut down. However, all other essential activities (like dewatering, ventilation etc.) to ensure safety of the mine are being continued. The mills at Jaduguda and Turamdih were under normal operation. Tummalapalle mill is under trial operation.

(a) Renewal of Licence for Operation of Banduhurang Mine

The Licence for operation of Banduhurang mine was valid till June 30, 2021. UCIL submitted the applications for renewal of the licence/ authorization. UCIL application was reviewed in AERB following multi-tier review process. Safety review indicated that operational & radiological status of the facility was satisfactory. The average individual doses of the mine workers were well within the regulatory limit. Radioactive waste discharged/transferred from the facility were within AERB authorized limits. The average Radon concentration and Gamma dose rate were within the permissible limit. Based on satisfactory review AERB had renewed the Licence for operation and authorization for disposal/transfer of radioactive waste of Banduhurang mine for next five years i.e. up to June 30, 2026.

(b) Consent for Trial Operation of Tummalapalle Mill, UCIL

The Consent for trial operation and the authorization for disposal/ transfer of radioactive waste under The Atomic Energy (Safe Disposal of Radioactive Waste) Rules, 1987 of Tummalapalle mill were valid up to June 30, 2021. UCIL submitted application for regular operation of Tummalapalle mill and also requested for extension of existing authorization for disposal/transfer of radioactive wastes of Tummalapalle mill. UCIL application was reviewed in AERB following multi-tier review process. Safety review indicated that work towards resolution of pending issues are in progress and will take some more time. In view of this AERB had extended the validity of the existing consent for trial operation and authorization for disposal/transfer of radioactive wastes of Tummalapalle mill for one year i.e. up to June 30, 2022.

(c) Renewal of Licence of Turamdih Mill, UCIL

The Licence for operation of Turamdih mill was valid till February 28, 2021. UCIL submitted applications for renewal of the licence/authorization. UCIL application was reviewed in AERB following multi-tier review process. Safety review indicated that operational & radiological status of the facility was satisfactory. The average individual doses of the mill workers were well within the regulatory limit. Radioactive waste discharged/transferred from the facility were within AERB authorized limits. Based on satisfactory review AERB had renewed the Licence for operation and authorization for disposal/transfer of radioactive waste of Turamdih mill for next five years i.e. February 28, 2026.

(d) Extension of validity of Consent for Construction of Tailings Pond & Dam of Tummalapalle Mill

The consent for construction of tailings pond and dam (including check dam) of Tummalapalle mill was valid till March 31, 2021. However, due to unforeseeable reasons, the construction work got delayed and could not be completed. In view of this, UCIL had submitted application for extension of validity of the existing consent for another five years i.e. till March 31, 2026 to enable completion of remaining work such as construction of new spill way and raising the dam height. UCIL application was reviewed in AERB. Based on satisfactory review, AERB had extended the validity of existing consent for construction for five years i.e. up to March 31, 2026.

(ii) IREL (India) Ltd.

Rare Earth Division (RED) at 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., Odisha Sand Complex (OSCOM), Manavalakurichi and Chavara were operational.

(a) Renewal of Licence for Operation of Rare Earth Extraction Plant (REEP), IREL (India) Ltd., OSCOM

The Licence for operation of Rare Earth Extraction Plant (REEP) [earlier named as Monazite processing plant (MoPP)] of IREL (India) Ltd. OSCOM, Odisha was valid till April 30, 2021. IREL (India) Ltd. submitted applications for renewal of the licence/authorization. The applications were reviewed in AERB following multi-tier review process. Safety review indicated that IREL (India) Ltd. had addressed most of the regulatory pending issues. Operational & radiological status of the facility was satisfactory. Based on satisfactory review, AERB renewed the Licence for operation and authorization for disposal/transfer of radioactive waste of REEP for remaining 4 years i.e. up to April 30, 2025.

(b) Permission for Setting Up a Separate Facility for Processing Lean Rare Earth (RE) Chloride Solution at Rare Earth Extraction Plant (REEP), at IREL (India) Ltd., OSCOM

IREL (India) Ltd. had submitted proposal for setting up of a separate facility for processing Lean Rare Earth (RE) Chloride solution at Rare Earths Extraction Plant (REEP) of OSCOM. The proposal was reviewed in AERB. Based on satisfactory review AERB granted the permission for setting up of a separate facility for processing lean Rare Earth (RE) Chloride solution at Rare Earth Extraction Plant (REEP) at IREL (India) Ltd., OSCOM.

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

All the plants of NFC, Hyderabad and ZC, Pazhayakayal operated safely during the year.

(a) Renewal of Licence for Operation of Zirconium Complex, Pazhayakayal

Licence for operation of ZC, Pazhayakayal under The Factories Act, 1948 (and rules framed thereunder) was valid up to June 30, 2021. ZC, Pazhayakayal submitted application for renewal of Licence for operation beyond this period. This application was reviewed in AERB following multi-tier review process. Safety review indicated that during the Licence period, ZC has operated within the licensed capacity and operational & safety performance has been satisfactory. In-Service Inspections of plant SSCs and civil structures are being carried out as per the requirements. Based on satisfactory review, AERB renewed the Licence for operation of ZC, Pazhayakayal for five years i.e., June 30, 2026.

(b) Extension of validity of Consent for Construction of Pilot Plant at New Uranium Oxide Fuel Plant (NUOFP), NFC, Hyderabad

Consent for construction of pilot plant for process parameter optimization of Uranium Ore Concentrates at NUOFP-NFC was valid up to March 31, 2021. NFC had submitted application for extension of existing consent of construction up to May 31, 2022 for completion of the pending construction activities. NFC submitted that construction and receipt of some equipment got delayed due to lockdown imposed in view of outbreak of COVID-19. Based on satisfactory review of application, AERB extended the consent for construction of pilot plant at NUOFP-NFC up to May 31, 2022.

(c) Extension of validity of Clearance for Siting & Construction of Magnesium Recycling Technology Development & Demonstration Facility (MRTDDF) at Zirconium Complex (ZC), Pazhayakayal

The clearance for siting & construction of Magnesium Recycling Technology Development & Demonstration Facility (MRTDDF) at Zirconium Complex (ZC), Pazhayakayal was valid up to September 30, 2021. In order to complete the pending activities, ZC had submitted application for extension of existing clearance to AERB. Based on the satisfactory review of ZC application, AERB had extended the validity of existing clearance for siting & construction of MRTDDF at Zirconium Complex, Pazhayakayal initially up to December 31, 2021 and then March 31, 2023.

(iv) Heavy Water Plants (HWP)

Heavy water plants at Kota, Manuguru, Thal and Hazira were operational. HWPs at Baroda and Talcher remained under shutdown due to unavailability of feed synthesis gas from fertilizer plant. Heavy water production facility at HWP-Tuticorin has been declared as 'CLOSED'. Diversified activities at HWP-Baroda, Talcher and

Tuticorin were operational. Technology Demonstration Plant (TDP), Chembur is under shutdown due to non-availability of feed phosphoric acid from fertilizer plant. However, trial operation for developmental activities were carried out. During the year following Licence applications were reviewed:

(a) Renewal of Licence for Operation of HWP-Baroda

The Licence for operation of HWP-Baroda under the Factories Act, 1948 (and rules framed thereunder) was valid up to May 31, 2021. HWP-Baroda had submitted the application for renewal of the Licence beyond May 31, 2021. This application was reviewed in AERB following multi-tier review process. Safety review indicated that during the existing Licence period, the facilities at HWP-Baroda have operated within the licensed capacity. The performance of the facility with respect to operation and safety has been satisfactory. In-service Inspection of the SSCs was carried out as per the ISI schedule. Based on the satisfactory review, AERB renewed the Licence for operation of HWP-Baroda for a period of five years i.e. up to May 31, 2026.

(b) Renewal of Licence for Operation of TDP-Chembur

The Licence for operation of Technology Demonstration Plant (TDP), Chembur under The Atomic Energy Act, 1962 & the Factories Act, 1948 (and rules framed thereunder) and authorization for safe disposal/transfer of radioactive wastes under GSR-125 were valid up to October 31, 2021. TDP-Chembur had submitted the applications for renewal of these licences/authorizations to AERB. These applications were reviewed in AERB following multi-tier review process. Safety review indicated that during the Licence period, plant remained under shutdown condition due to non-availability of feed of phosphoric acid from RCF and was involved in other developmental activities. The performance of plant with respect to operational, radiological and industrial safety was satisfactory. In-Service Inspection (ISI) of Systems, Structures and Components (SSCs) was carried out as per the approved ISI programme and did not reveal any major degradation. Based on satisfactory review, AERB renewed the Licence for operation and authorization for transfer/disposal of radioactive waste for next five years i.e. up to October 31, 2026.

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

Periodic radiological reports submitted by the facilities were reviewed by AERB. No abnormality was observed during review.

1.5 PROBABILISTIC SAFETY STUDIES

(i) Review of Human Reliability Analysis (HRA) of PFBR – PSA Level 1 (FP, IE)

As a part of PSA Level 1 (Full Power, Internal Events) of PFBR, Human Reliability Analysis (HRA) report was reviewed. The contribution of Human Error Probabilities (HEP) to Core Damage Frequency (CDF) were found to be very less.

(ii) Review of MAPS – PSA Level 1(FP, IE)

As a part of periodic safety review (PSR), PSA Level 1(FP, IE) (Rev.2) reports of MAPS were reviewed. The updated reliability analysis of frontline and support systems w.r.t. plant specific data was also reviewed. The estimated Core Damage Frequency (CDF) for Level 1(FP, IE) (rev.2) of MAPS was found to be one order lower than the accepted core damage frequency.

(iii) Review of Level-1 Low Power and Shutdown PSA of TAPS-3&4

The Low Power and Shut down (LPSD) PSA Report of TAPS-3&4 was reviewed. The study was focused on assessment of CDF at cold shutdown and start-up & low power operation of the reactor. The calculated mean core damage frequency during shutdown and low power mode of operation are found to be two orders and five orders less than that due to FP, IE which is well within the regulatory criteria.

(iv) Review of Level 1 Internal Fire PSA reports

Systematic assessment of fire hazard is one of the important elements in implementing the fire protection in plants. The review of internal fire PSA Level 1 for RAPS-2, NAPS-1&2, KAPS-1&2 and KAPP-3&4 has been completed. The estimated core damage frequency due to internal fire is of three order less than the accepted core damage frequency.

(v) Review of Level 1 Internal Flood PSA reports

Internal floods may result from component failures or from incorrect operation of the equipment and systems. An internal flood may potentially lead to failure of the systems maintaining the heat sinks and then by contributing to failures of engineered systems designed to mitigate such events. The review of internal flood PSA Level 1 for TAPS-1&2, RAPS-3&4 and KAPP-3&4 was carried out.

(vi) Review of Level 1 External Flood PSA reports

Extreme phenomena, such as storm surges or high river water levels, may endanger the safety of NPPs by inundation of the plant site with subsequent damage on safety-related buildings. External floods are important to consider in a PSA studies as they represent an important class of common cause. Review of External Flood PSA of MAPS-1&2 and KAPP-3&4 was carried out.

(vii) Review of Level 2 PSA reports

A Level 2 PSA taking inputs from Level 1 PSA results, quantifies the magnitude and frequency of radioactive release to the environment following core damage and containment failure. It provides insights into severity of accident sequences resulting in core damage, consequent radioactive releases into containment, time and mode of containment failure, inventories of radioactivity released to the environment and ways of improving the mitigation and management of core damage accidents. The review of KKNPP-1&2 Level-2 PSA was carried out.

1.6 SAFETY ASSESSMENT

(i) Core Safety Assessment

Design review and analysis activities were carried out during the year towards core safety assessment of Indian NPPs. The safety review related to KAPP-3, India's first 700 MWe PHWR, included review of commissioning results of Phase-C experiments conducted to ascertain various reactor physics aspects /systems' performance; 700 MWe PHWR design issues related to Regional Overpower Protection System (ROPS) and issues related to bundle power estimation uncertainties. The review of the Commissioning Reports (CRs) on performance of Reactor Regulation System (RRS), ROPS and Flux Mapping System (FMS) was also carried out. The safety review of CRs of xenon induced spatial oscillations in Phase-C commissioning was carried out wherein measured characteristics of spatial xenon oscillations were assessed against the design predictions.

The salient issues covered under the safety review of operating NPPs included reload cycle reports of KKNPP-1& 2, application for seeking permission to use two-pitch long integral SPNDs, neutronics aspects of TAPS-3 SER on actuation of RPS-1 & RPS-2 following malfunctioning of Boiler Feed Pumps (BFPs) common Speed controller and an application for calandria filling in TAPS-3&4. Safety review of FBTR's proposal for its 30th campaign wherein the core power has been increased to 40 MWt for the first time, was also carried out. Safety review activities also covered Technical Specifications clauses of KAPP-3 on issues related to the FMS operation with partial AR IN and bundle power safety limits, Technical Specifications clauses related to requirement of boron addition on failure of Primary Shutdown System (PSS) in standard 220 MWe PHWRs.

(ii) Safety Assessment of Kudankulam (KK) VVER-1000 Reactor Fuel Loading Patterns

The VVER-1000 reactors located in Kudankulam nuclear power plant (KKNPP) employ a batch refueling with the operating cycle length of 300 effective full power days (EFPDs). For each unit, before refueling for any next cycle of operation, reload safety evaluation reports (RSER) comprising of design calculations on fuel loading patterns are submitted to AERB to obtain the necessary clearances for fuel unloading/loading during the upcoming refueling shutdown of units. In order to support the safety review of the fuel loading pattern for each of the above refueling cycles, independent verification of design calculations was carried out using indigenous computer code systems. Key safety parameters were evaluated and verified against the design intent and the acceptance criteria.

1.7 OVERALL SAFETY PERFORMANCE OF THE NUCLEAR FACILITIES

1.7.1 Safety Performance of Nuclear Facilities Under Construction

(i) KKNPP–3 to 6

Construction activities are in progress at KKNPP-3 to 6 sites. During 2021, there were no major reportable incident calling for enforcement action at KKNPP-3 to 6.

(ii) RAPP-7&8

Construction activities are in progress at RAPP-7&8 sites. During 2021, there were no major reportable incident calling for enforcement action at RAPP -7&8.

(iii) GHAVP-1&2

Construction activities are in progress at GHAVP-1&2 sites. During 2021, there were no major reportable incident calling for enforcement action at GHAVP-1&2.

(iv) PFBR

Pre-commissioning/commissioning activities at PFBR are in progress. During 2021, there was no major reportable incident at PFBR calling for enforcement actions during the period.

(v) KAPP-3&4

There were two accidents in KAPP-3&4 during pre-commissioning activities. AERB reviewed these incidents and measures to prevent recurrences of such incidents in future were recommended and conveyed to the site for compliance.

(vi) DFRP

There was no major reportable incident calling for enforcement action during commissioning activities at DFRP.

(vii) NFC-Kota

There was no major reportable incident at NFC-K calling for enforcement action during the period.

1.8 SAFETY PERFORMANCE OF NUCLEAR FACILITIES IN OPERATION STAGE

During this year, RAPS-2 to 6, KGS-1 to 4, MAPS-2, NAPS-1&2, KAPS-1&2, TAPS-3&4 and KKNPP-1&2 were operational. RAPS-1 is under shutdown since October 2004 and reactor core is defueled.

MAPS-1 is under shutdown since January 30, 2018 due to leak from two pressure tubes O-09 & Q-09 and North End Shield. Investigations towards establishment of root cause of pressure tubes & end shield leak/degradation, rectification of end shield leak, fitness-for-service assessment of coolant channels & end shield are in progress.

TAPS-1 & TAPS-2 are also under shutdown since January 08, 2020 and July 13, 2020 respectively due to observed degradation in primary system piping weld joints during in-service inspection. Station is in process of replacement/repair of all Class-I piping vulnerable to IGSCC.

In the year 2021, there were total 31 significant events rated as zero level on INES scale in NPPs. All the 31 significant events were reviewed in detail in AERB to see the adequacy of investigations, corrective actions, lessons learnt and the need for further regulatory actions. Details of the significant events are given in section 1.11.

1.9 R&D UNITS AND OTHER FACILITIES IN CONSTRUCTION AND OPERATION

Safety review of Variable Energy Cyclotron Centre (VECC), Raja Ramanna Centre for Advanced Technology (RRCAT), Indira Gandhi Centre for Atomic Research (IGCAR), Electronics Corporation of India Limited (ECIL) and Board of Radiation & Isotope Technology (BRIT) was done apart from the Fuel Cycle Facilities. The status of R&D units and other facilities is presented in Table 1.10.

Table 1.10: Status of R&D 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	August 31,2022
	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	July 13, 2022
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
PARF	TWINDUS LINAC-1 Agricultural Radiation Processing Facility (ARPF)	In operation	Electron Acceleration, 10 MeV, 5 kW Technology Demonstration for Food Irradiation	January 11, 2024
	TWINDUS LINAC-2	In operation	Electron Acceleration, 10 MeV, 5 kW	January 11, 2024
	TWINDUS LINAC-3	Commissioning	Electron Acceleration 10 MeV, 10 kW	July 30, 2022
	INDUS-1	In operation	450 MeV, 100 mA Electron Storage Ring	September 30, 2023
	INDUS-2	In operation	2.5 GeV, 200 mA Synchrotron Radiation Source (SRS)	March 31, 2026
LASER	1 PW Laser System	Construction Completed	1 PW (femto second)	----
Superconducting RF Cavity	Horizontal Test Stand for Superconducting RF Cavities	Commissioning and Operation	SCRF Cavity at 650 MHz	June 20, 2022
Facilities Operated by IGCAR, Kalpakkam, Tamil Nadu				
Accelerator	1.7 MV Tandetron Accelerator	In operation	1.7 MV	August 31, 2021 (Not in operation because of non-availability of RSO in the institute)
	150 kV Accelerator	In operation	150 kV	August 31, 2021 (Not in operation because of non-availability of RSO in the institute)

Type of Facility	Name	Functional Status	Scope of the Facility	Validity of Current Licence
Facilities Operated by ECIL				
Electronic Component Development	ECIL, Hyderabad	In operation	Production of Instrumentation, Control & Communication Systems and other Electronic Components	June 30, 2025
	ECIL, Tirupati	In operation	Production of Nuclear Industrial Instrumentation Systems, EVM & VVPAT Power Packs etc.	October 31, 2026
Facilities Operated by BRIT				
Board of Radiation and Isotope Technology	BRIT, Navi Mumbai	In operation	Production of Radio-Isotopes used Radiation Facilities, Radio- Pharmaceutical mainly for Nuclear Medicine Application, Radiation Processing etc.	January 31, 2024
	BRIT-RAPPCOF, Kota	In operation	Production of Radio-Isotopes mainly for Radiation Processing Plants	January 31, 2024

1.9.1 Variable Energy Cyclotron Centre (VECC)

The Room Temperature Cyclotron (K-130) was under operation delivering alpha and proton beams of various energies and intensities. Commissioning of Super-conducting cyclotron and Radioactive Ion Beam facility is in progress. The Stage-1 commissioning consent was issued to medical cyclotron facility, which will be used, for commercial production of isotopes for Positron Emission Tomography (PET) and Single Photon Emission Computed Tomography (SPECT) as well as high end technological research. During the year, following proposal was reviewed by AERB.

Stage-1 Commissioning of Medical Cyclotron, VECC, Kolkata

VECC submitted application for extension of Stage-2 Commissioning of Medical Cyclotron and its associated beamlines. The application was reviewed by AERB and extended till July 13, 2022.

1.9.2 Raja Ramanna Centre for Advanced Technology (RRCAT)

(a) INDUS-1 Synchrotron Radiation Source (SRS) was under operation with beam energy of 450 MeV and beam current of 100 mA delivering synchrotron radiation through fourteen beamlines. INDUS-2, which is a synchrotron cum electron storage ring, was under operation at 2.5 GeV (max) beam energy and beam current of 200 mA (max). Twelve beamlines of INDUS-2 have already been authorised by AERB for carrying out experiments. In addition to these, major accelerators, other accelerators and Laser Facilities/Projects at RRCAT are being periodically reviewed.

(b) Commissioning Consent for Stage- 2 of TWINDUS LINAC-3

RRCAT is in process of developing RF based Linear Accelerator. After completion of Stage-1 of Electron Accelerator (10 MeV beam energy with 5 kW beam power), RRCAT applied for Stage-2 Commissioning Consent for TWINDUS LINAC-3 at 10 MeV beam energy with 10 kW beam power. After safety review AERB granted commissioning consent for stage-2 with enhanced power 10kW up to July 30, 2022.

1.9.3 Electronics Corporation of India Limited (ECIL)

ECIL facilities at Hyderabad and Tirupati operated safely during the year. However, operations of all these facilities were suspended during the period of nation-wide lockdown due to COVID-19 pandemic.

(a) Renewal of Licence for Operation of ECIL, Hyderabad

The Licence for operation of ECIL, Hyderabad was issued under the Factories Act, 1948. The facility submitted an application for renewal of licence for operation, which was reviewed in AERB following multi-tier review process. It was noted that safety performance of ECIL has been satisfactory during licensing period. Based on the satisfactory safety review, AERB renewed the licence for operation of ECIL under the Factories Act, 1948 (and rules framed thereunder) for next five years i.e. up to June 30, 2025.

(b) Renewal of Licence for Operation of Electronics Corporation of India Limited (ECIL), Tirupati

Licence for operation of ECIL-Tirupati was valid till October 31, 2021. ECIL had submitted application for renewal of Licence for operation for a period of next five years to AERB. This application was reviewed in AERB following multi-tier review process. Safety review indicated that ECIL-Tirupati is engaged in operation of smart cards printing & packaging, assembly of power packs for Electronic Voting Machines (EVMs) & Voter Verifiable Paper Audit Trial (VPAT) manufacturing of thickness gauging system (nucleonic gauges), Environmental Radiation Monitors (IERMON), etc. During the Licence period, ECIL-Tirupati had operated within the licensed capacity. The performance of the facility with respect to operational and industrial safety was satisfactory. No reportable injuries and fire incidences were reported during the Licence period. Based on satisfactory review, AERB had renewed the Licence for operation of ECIL-Tirupati for a period of five years i.e. up to October 31, 2026.

1.9.4 Board of Radiation & Isotope Technology (BRIT)

BRIT facilities at Navi Mumbai and its Regional centres at various locations in the country are involved in production of radio-isotopes used in radiation facilities as well as radio-pharmaceuticals used mainly in nuclear medicine application. During 2021, there was no reportable incident at BRIT.

1.10 INDUSTRIAL SAFETY OF NUCLEAR FACILITIES

Industrial Safety Awards and Fire Safety Awards are given by AERB to promote Industrial Safety and Fire Safety in DAE Units under its preview. The awards for the year 2020 were presented to the winner DAE units during the 37th DAE Safety & Occupational Health Professionals Meet, 2021 jointly organized by AERB and IREL (India) Limited.

1.10.1 Industrial Safety Award

AERB presents Industrial Safety awards every year to the DAE units which achieve highest performances in Industrial Safety. These 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 categories. Winners of the AERB Industrial Safety awards -2020 in various categories are as follows.

Table 1.11: List of Winners for Industrial Safety Award for the year-2020

Categories/Groups	Winners
Construction Units	Kakrapar Atomic Power Project - 3&4
Production Units –I (NPPs & HWPs)	Nuclear Fuel Complex, Hyderabad Narora Atomic Power Station
Production Units –II (Others)	IREL (India) Ltd., OSCOM
R&D and other Low Risk Units	Heavy Water Plant - Talcher

Glimpses of Industrial Safety Award-2020

1.10.2 Fire Safety Award

Fire safety award was 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 awards are given 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 – 2020 in these categories.

Table 1.12: List of Winners for Fire Safety Award for the year -2020

Categories/Groups	Winners
Category- I (high fire risk units)	Kakrapar Atomic Power Station-1&2
Category- II (low fire risk units)	Kakrapar Atomic Power Project-3&4

Glimpse of Fire Safety Award-2020

1.10.3 Occupational Injury Statistics of DAE Units for year 2020

The compilation of Occupational Injury Statistics for the year 2020 for DAE units (other than BARC facilities, AMD and mines of IREL (India) Ltd. & UCIL) provides the data on accidents and analysis of number of injuries and loss of man-days. Details are presented in Table 1.13.

During the calendar year 2020, there were 18 reportable injuries including 2 fatalities with a loss of

12,733 man-days compared to 32 reportable injuries including 6 fatalities with a loss of 37,042 man-days in 2019. Total man-hour worked in 2020 was 12,71, 48,021 as compared to that of 16,41,84,513 in 2019. During the calendar year 2020, two fatalities occurred at KKNPP-3&4.

The year 2020 recorded a Frequency Rate (FR) of 0.13 as compared to 0.19 in the year 2019 and a Severity Rate (SR) of 100.14 as compared to 225.61 in 2019. Similarly, the year 2020 recorded an Injury Index of 0.013 as compared to 0.044 in the year 2019 and an Incidence Rate of 0.41 as compared to 0.499 in 2019.

There was no notifiable disease reported during the period from any of the operating units of DAE under the purview of AERB.

Year-wise Frequency Rate (FR), Injury Index (II), Severity Rate (SR), and Incidence Rate (IR) in DAE Units are shown in Figure 1.10.3.1, 1.10.3.2, 1.10.3.3 and 1.10.3.4 respectively.

Table 1.13: Unit wise Comparison of Reportable Occupational Injuries in DAE Units for year - 2020

Unit	C1	C2	C3	C4	C5	C6	C7	C8	C9
	No. of Reportable Accidents	No. of Man-days Lost	No. of Fatal Injury	No. of Employ-ees	Number of Man-hours Worked	Frequen-cy Rate	Severity Rate	Injury Index	Incidence Rate
NP Plants	4	191	0	11,799	3,30,06,361	0.12	5.79	0.0007	0.34
Const. Projects	7	12,213	2	9,796	4,60,43,243	0.15	265.25	0.0403	0.71
HWPs	1	58	0	4,169	1,56,74,398	0.06	3.7	0.0002	0.24
IREL (India) Ltd.	0	0	0	577	13,91,148	0	0	0	0
NFC & ZC	0	0	0	4,358	85,12,807	0	0	0	0
UCIL Mills#	2	106	0	2,721	56,33,848	0.35	18.81	0.0067	0.74
ECIL	1	23	0	2,367	58,29,040	0.17	4	0.0007	0.42
IGCAR	2	52	0	2,928	52,03,808	0.38	9.99	0.0038	0.68
BRIT#	0	90	0	998	11,02,248	0	81.65	0	0
RRCAT	0	0	0	0	31,91,120	0	0	0	0
VECC	0	0	0	399	15,60,000	0	0	0	0

 # - The man-days lost are due to reportable accident occurred in the year 2019 for BRIT and for UCIL Mills namely, UCIL-Jaduguda

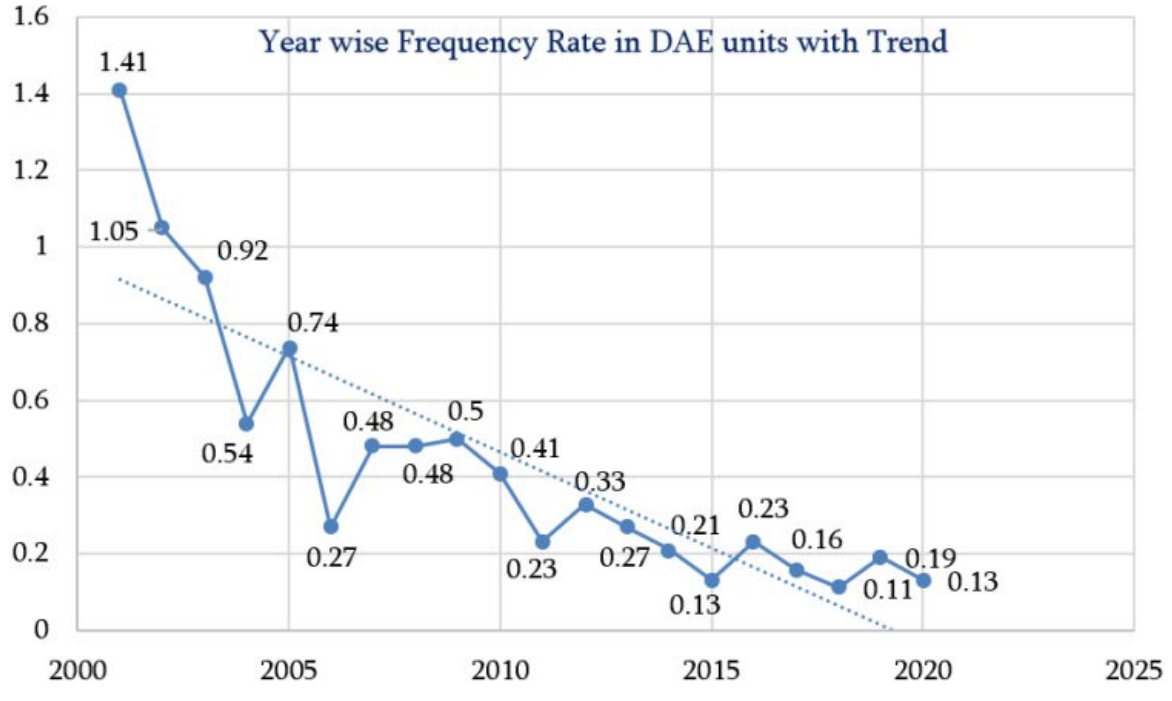


Figure-1.10.3.1: Year wise Comparison of Frequency Rate along with its Trend

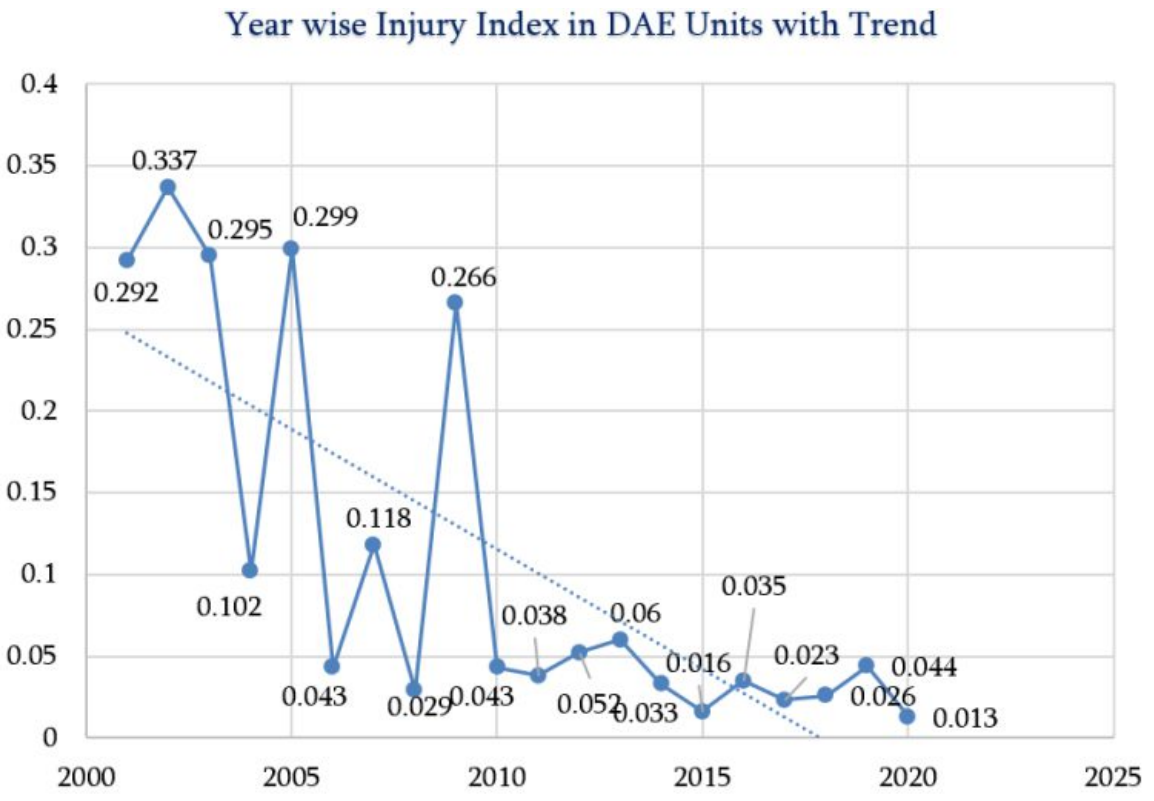


Figure-1.10.3.2: Year wise Comparison of Injury Index Rate along with its Trend

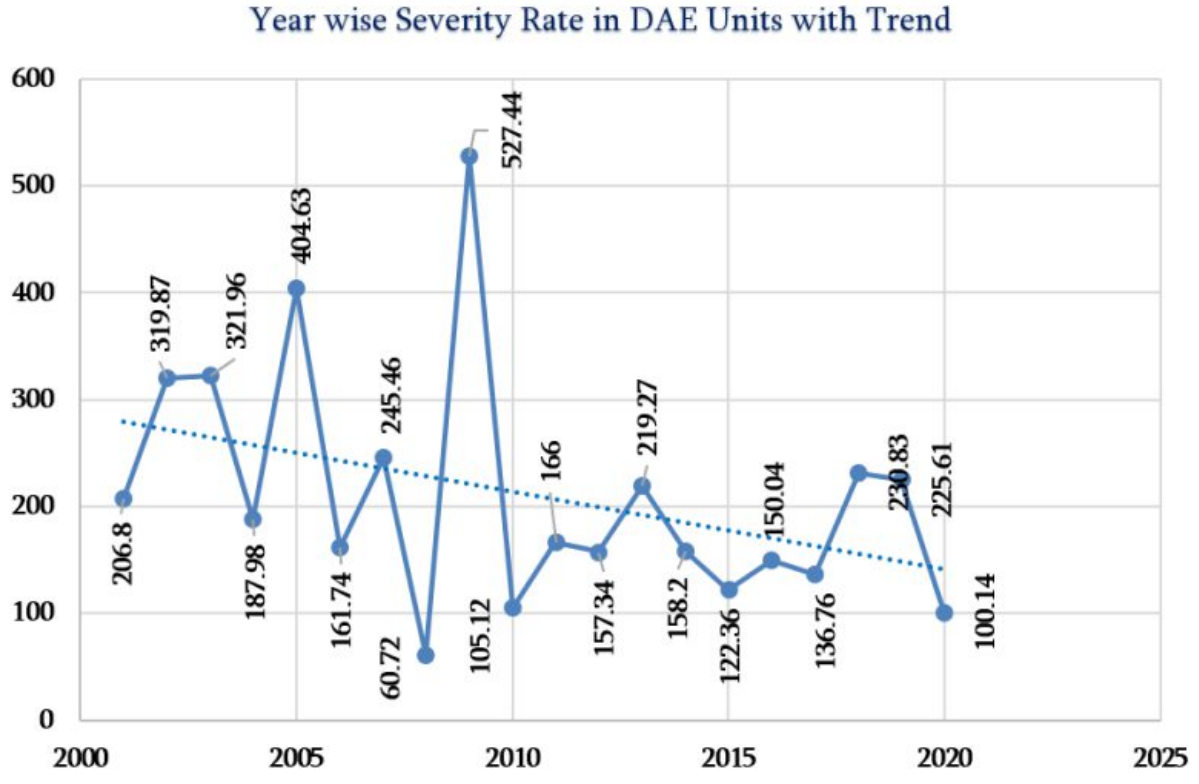


Figure-1.10.3.3: Year wise Comparison of Severity Rate along with its Trend

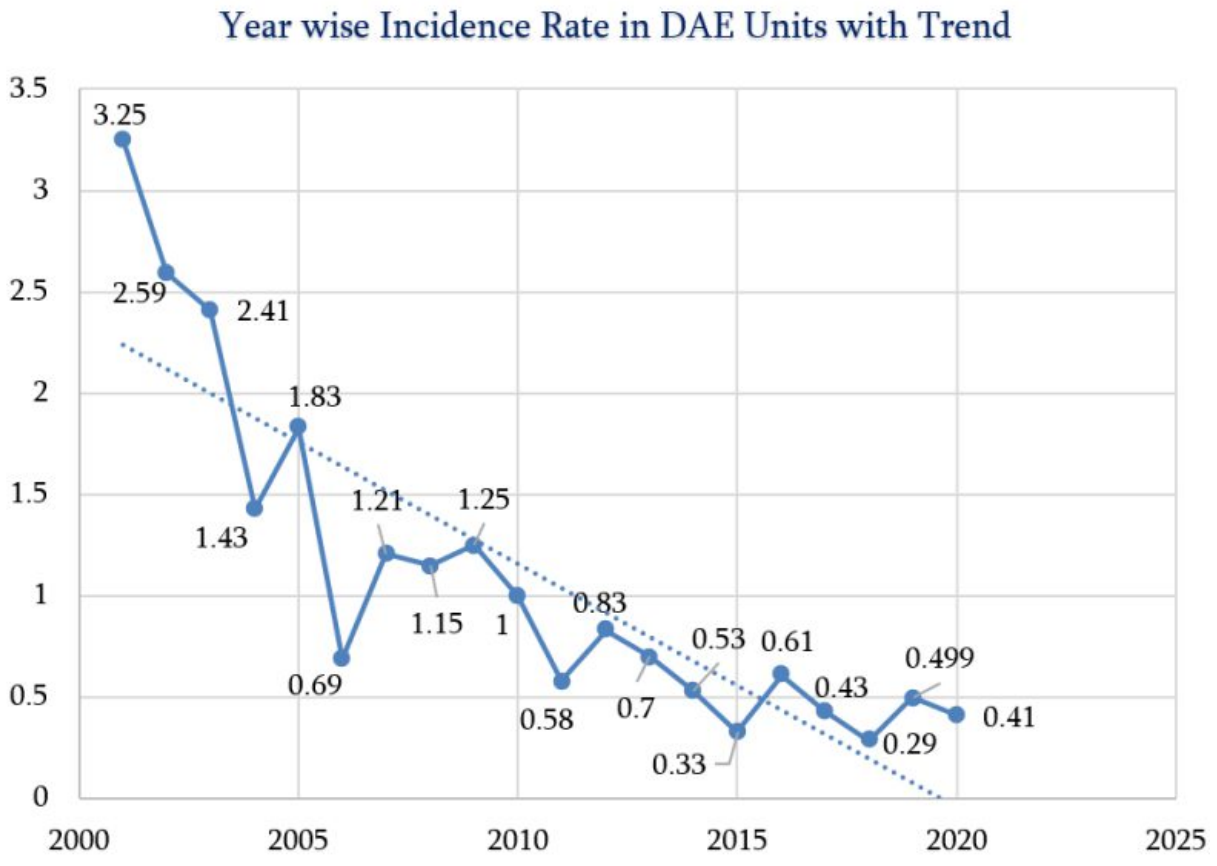


Figure 1.10.3.4: Year wise Comparison of Incidence Rate along with its Trend

1.11 SIGNIFICANT EVENTS AND ENFORCEMENT ACTIONS

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,

(i) Events (ii) 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 1.11.1 below.

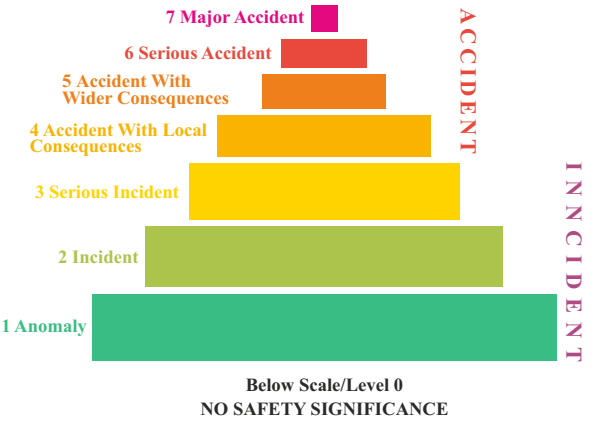


Figure-1.11.1: International Nuclear & Radiological Event Scale

Events rated at Level 4 and above are termed as 'Accidents'. The accidents at Chernobyl NPP in former USSR (now in Ukraine) in April 1986 and Fukushima NPPs in Japan in March 2011 were rated at Level 7 on INES. Events rated at levels 1, 2 and 3 are called 'Incidents'. The level 0 or below scale means events that have no nuclear and radiological safety significance.

1.11.1 Significant Events and INES Rating w.r.t. NPPs

All the significant events reported were reviewed in detail by AERB and measures to prevent recurrence of such events were recommended.

(a) Significant Events in NPP under Construction/ Commissioning

Two significant events were reported during Phase-C commissioning of KAPP-3. The significant events are rated at Level 0 on International Nuclear and Radiological Event Scale (INES) of International Atomic Energy Agency (IAEA).

(i) KAPP-3 Reactor Trip on PHT High Pressure

During Phase-C Commissioning of KAPP-3, the Reactor was critical at 0.008% FP. PHT temperature was 35°C and pressure was 22.5 kg/cm^2 with all four shutdown cooling pumps running. Changeover to the redundant control node of PHT pressure control system, led to both feed control valves(CVs) full opening, both bleed control valves full closing; which in turn led to the reactor trip on PHT high pressure signal.

Subsequently, on investigation it was observed that improper resetting of Control Node (which remained as a latent failure) led to failsafe command to PHT feed and bleed CVs when control was transferred from the redundant Control Node to the improperly reset control node. Significant event report was reviewed in detail by AERB and corrective measures to prevent recurrence of such event was recommended.

(ii) KAPP-3 Reactor Trip due to Spurious Actuation of Seismic Trip during Thunder Storm/ Lightning

During Phase-C Commissioning of KAPP-3, the Reactor was critical at 0.85% FP. PHT temperature was 41°C and pressure was 30 kg/cm^2 with all four shutdown cooling pumps running. Thunderstorm and heavy lightning in and around operating island area, led to induced voltage/noise pick-up by seismic switches in two protection channels and got spuriously actuated which led to the Reactor trip. Significant event report was reviewed by AERB and corrective measures to prevent recurrence of such event were recommended.

(b) Significant Events in NPPs under Operation

During the year 2021, a total of 31 significant events were reported from operating NPPs. All these events were rated at 'Level 0' on INES. The number of SERs in operating NPPs along with their ratings on INES are given in Table-1.14.

Table 1.14: INES Rating of Significant Events in NPPs Reported during the calendar year 2021

NPPs	INES Rating of Events		NPPs	INES Rating of Events	
	INES-0	INES-1		INES-0	INES-1
TAPS-1&2	0	0	NAPS-1&2	4	0
TAPS-3&4	4	0	KAPS-1&2	2	0
RAPS-1&2	4	0	KGS-1&2	2	0
RAPS-3&4	1	0	KGS- 3&4	3	0
RAPS-5&6	3	0	KKNPP-1&2	2	0
MAPS-1&2	6	0	-	-	-
Total	INES-0: 31		INES-1: 0		

For the purpose of analysis, the events reported in year 2021 were categorized as per the IAEA-IRS coding system. The classification of systems failed/affected during the significant events is given in Figure-1.11.2. The classification of direct causes and root causes of the significant events are given in Figure-1.11.3 & 1.11.4 respectively.

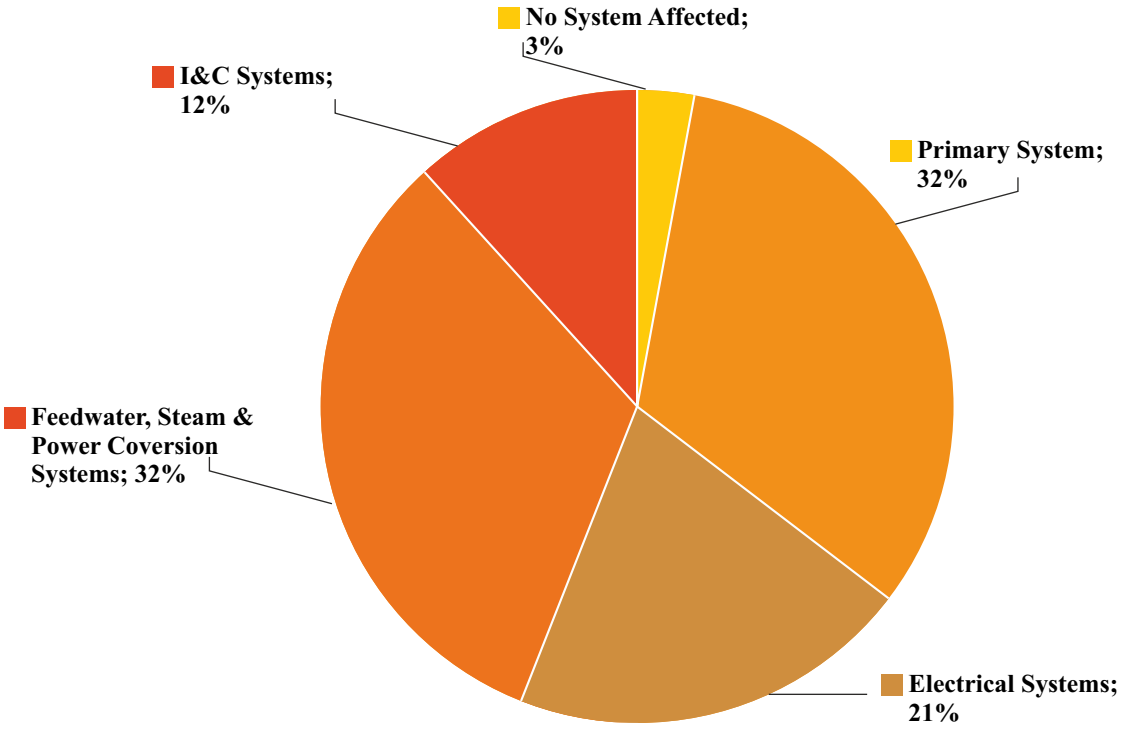


Figure 1.11.2: Classification of Failed/Affected System of SERs

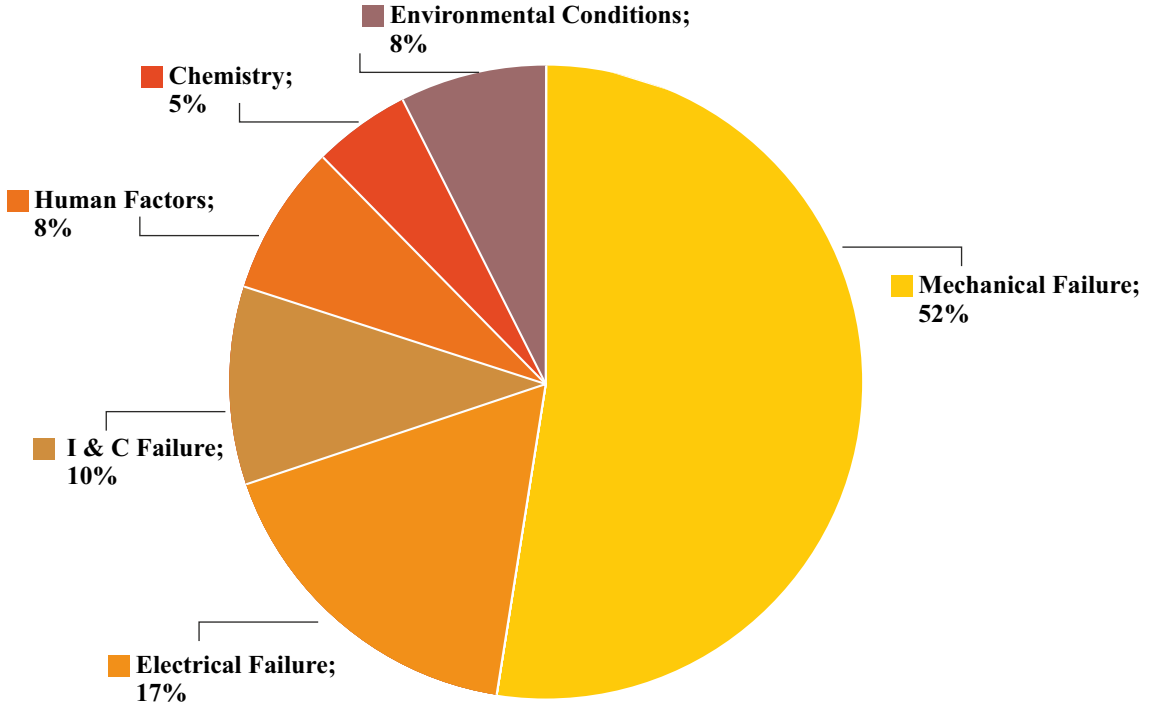


Figure 1.11.3: Classification of Direct Causes of SERs

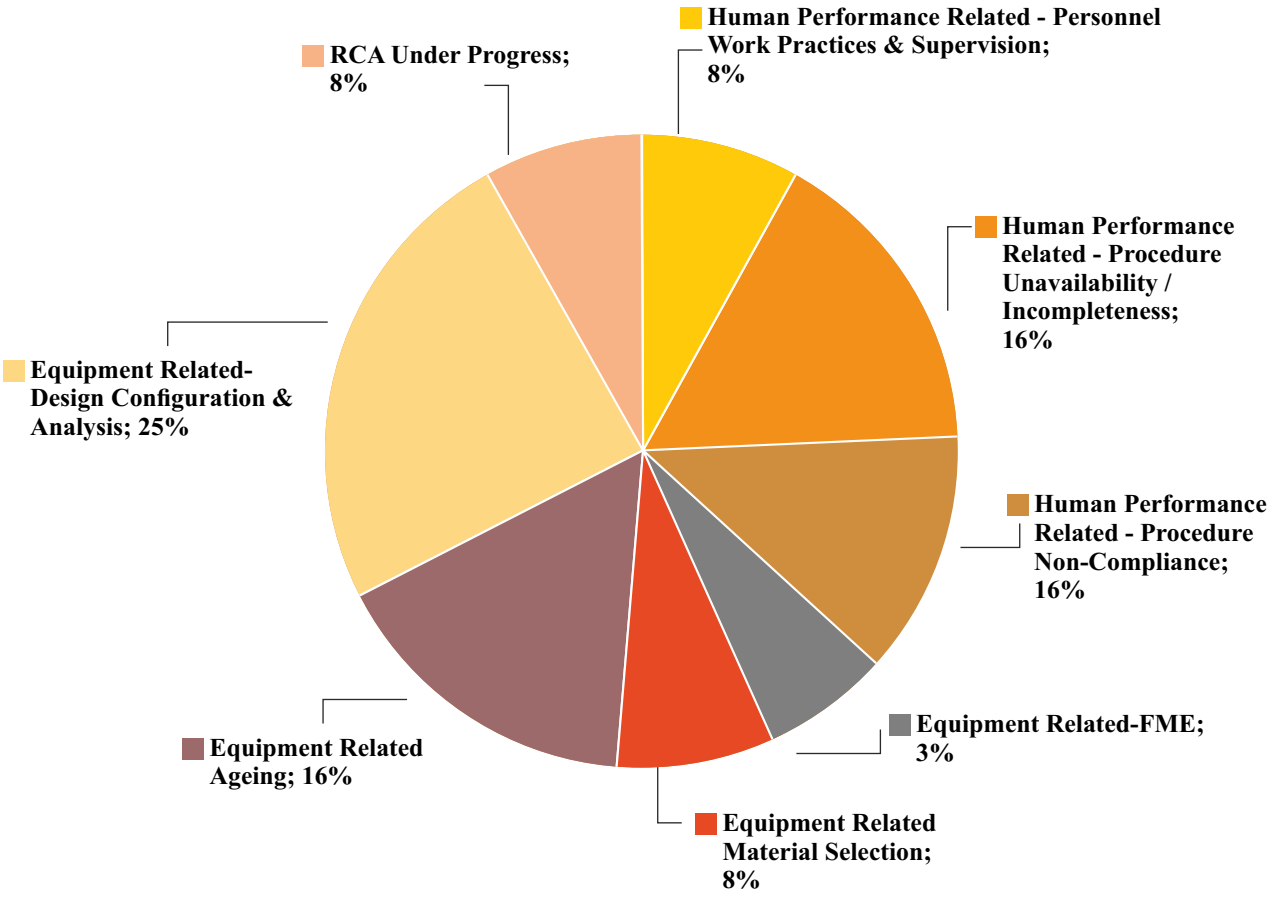


Figure 1.11.4: Classification of Root Causes of SERs

1.12 DEVELOPMENT OF SAFETY PERFORMANCE INDICATORS (SPI) FOR THE OPERATING NUCLEAR POWER PLANTS (NPP)

After satisfactory commissioning and demonstration for the safe operation of nuclear power plants (NPPs), ensuring all systems in place, technical as well as administrative, AERB grants licence for operation with stipulated conditions within which only the licensee can operate. The technical and administrative arrangements result in continuous monitoring of NFs and review of various aspects even within the licensed period as a part of safety review and assessment. AERB issues various consents for several practices in multiple stages of NPPs. AERB has developed Safety Performance Indicator (SPI) for operating NPPs. The value of SPI is a performance index on the radiological safety of the NPP. It is derived based on certain parameters such as Nuclear Safety, Radiation Protection, Radioactive Waste Management, Emergency Preparedness and Regulatory Compliance. Safety Performance Indicators (SPIs) are used for monitoring and assessing the safety performance of operating Nuclear Power Plants (NPPs). In 2021, AERB assessed the safety performance of operating NPPs from April 1, 2019, to March 31, 2020, using a comprehensive set of SPIs, which were refined based on its own experience and methodologies followed by other regulatory bodies worldwide. The performance of NPP is categorized as very good, good, and satisfactory and scope of improvement based on SPI with identified colour code as shown in the above figure. As per the above analysis, the safety performance was found in very good category.

Results of Safety Performance Assessment of Operating Power Plants (2019-2020)

Cat no.	Category	PHWRs																		BWRs		LWRs	
		RAPS-1&2		MAPS-1&2		KAPS-1&2		NAPS-1&2		KGS-1&2		RAPS-3&4		KGS-3&4		RAPS-5&6		TAPS-3&4		TAPS-1&2		KKNPP-1&2	
		U-1*	U-2	U-1	U-2	U-1	U-2	U-1	U-2	U-1	U-2	U-3	U-4	U-3	U-4	U-5	U-6	U-3	U-4	U-1	U-2	U-1	U-2
1	Nuclear Safety	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
2	Radiation Protection	●		●		●		●		●		●		●		●		●		●		●	
3	Radioactive Waste Management	●		●		●		●		●		●		●		●		●		●		●	
4	Emergency Preparedness	●		●		●		●		●		●		●		●		●		●		●	
5	Regulatory Compliance	●		●		●		●		●		●		●		●		●		●		●	

** RAPS-1 is under long shutdown with core in defueled condition*

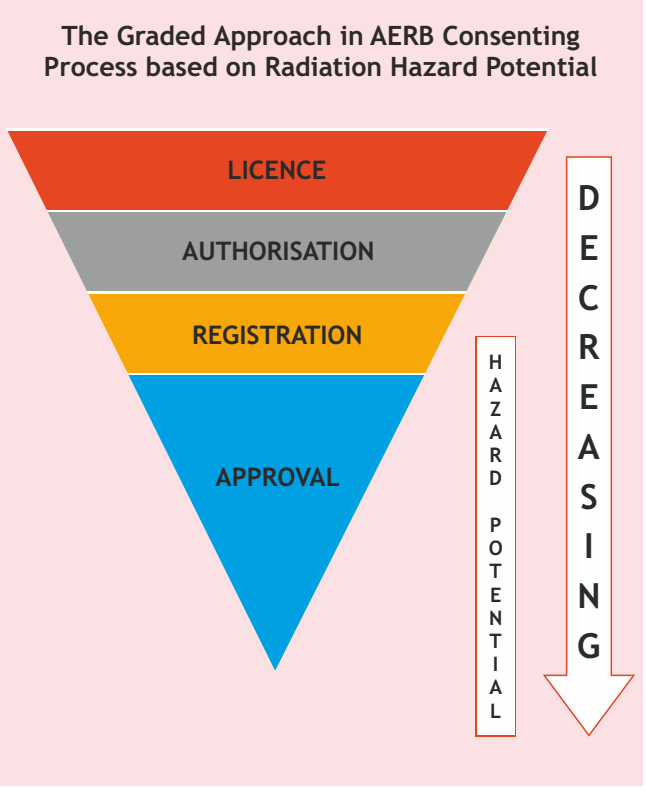
SPI Rating		Colour Coding
Very Good	बहुत अच्छा	
Good	अच्छा	
Satisfactory	संतोषजनक	
Scope for Improvement	सुधार की जरूरत	

CHAPTER 2

SAFETY SURVEILLANCE OF RADIATION FACILITIES

CHAPTER 2 - 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 and ingenious ways for societal benefit. The radiation sources have a wide range of applications in the industry, medicine, agriculture and research. 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.



2.1 SAFETY REVIEW MECHANISM OF RADIATION FACILITIES

As per the Atomic Energy (Radiation Protection) Rules, 2004, licences are issued to radiation facilities for operation from radiological safety stand point, which are categorized as Licence, Authorisation and Registration based on their hazard potential. AERB has a robust multi-tier review system for processing of applications for issuance of licences to radiation facilities. The process of issuance of various licences is as per AERB Safety Guide on 'Consenting Process for Radiation Facilities' (AERB/RF/SG/G-3). Accordingly, requirements are stipulated in respective Safety Codes for the facilities based on hazard potential and may require multiple stages of review, before issuance of Licence for operation. AERB also issues shipment approval to facilitate safe transport of radioactive materials.

Type Approvals are issued to manufacturer/supplier for equipment conforming to the safety 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 from radiological safety standpoint are witnessed by AERB on the first equipment installed in the country for issuance of Type Approval.

2.2 APPLICATIONS OF RADIATION SOURCES AND REGULATORY ACTIVITIES

A glimpse on various applications of radiation sources and status of licence/consent issued during the year to radiation facilities are detailed in following paragraphs.

2.2.1 Medical Applications of Radiation Sources

(a) Radiation Therapy

(i) Teletherapy

Teletherapy is a branch of radiation therapy, which deals with primarily treatment of cancer, using ionising radiation keeping the radiation source(s) at certain distance. The radioisotope like ^{60}Co emitting γ-ray and 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.

(ii) Proton Beam Therapy

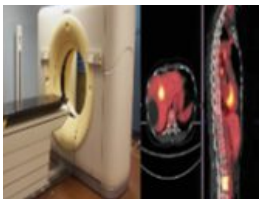
Beam of protons having energies 70 to 230 MeV are used for radiation therapy. Proton beams are specifically beneficial in treating paediatric cancers and deep-seated tumours more effectively than the conventional Gamma/X-ray radiation therapy. Proton

Therapy equipment is also a part of Teletherapy equipment, is of high radiation hazard potential.

(iii) Brachytherapy

In Brachytherapy, source is kept very near to 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.

(b) Nuclear Medicine



Nuclear medicine facility uses very small amount of radioactive material in the form of radio-pharmaceuticals (e.g. ^{99m}Tc, ^{131}I, ^{201}Tl and ^{18}F) for diagnosis and treatment. Imaging equipment such as PET-CT and SPECT are used in these practices. The facilities using radio-pharmaceuticals are of moderate-to-low radiation hazard potential.

(c) Diagnostic Radiology (X-ray)

X-rays are used in medical facilities as an important diagnostic tool. Following practices use X-ray for various diagnostic examinations. Following table provides the details of consents issued for Medical Radiation Facilities during the year.

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-sectonal images of the body. CT equipment pose moderate radiation hazard potential to both worker and patient.

Radiography and Fluroscopy

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.

The details of accumulated Medical Radiation Facilities/equipment and consents issued for various medical facilities during the year 2021 are given in Table 2.15.

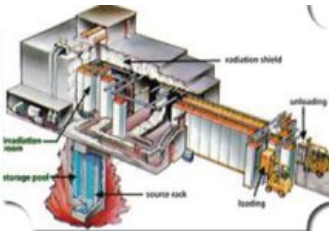
Table 2.15: Details of Consents issued for Medical Radiation Facilities during the year

Practices	Radiation Therapy	Nuclear Medicine	X-ray
Type of Consent ↓ / **Accumulated No. of Facilities (Equipment)** →	530 (767) Teletherapy + (372) Brachytherapy	401	69,164 (94,773)
Licence*	429	343	14,863
Permission for Import/Procurement of Equipment	85	47	11,995
Permission for Procurement of Radioactive Sources	428	1,698	—
Type Approval/Renewal (Equipment)	15	5	232
Layout Approval	197	106	---

**Licence includes Licence/Authorisation/Registration for various Radiation Facilities.*

2.2.2 Industrial Applications of Radiation Sources

(a) Radiation Processing Facilities (RPF)



RPF includes Gamma Radiation Processing Facility (GRAPF) /Gamma Irradiators and Industrial Accelerators Radiation Processing Facility (IARPF). These facilities are mainly used for radiation processing of food (i.e. inhibiting sprouting, delay in ripening, microbial decontamination, insect disinfestation, shelf-life extension etc.), sterilisation of healthcare products. The activity of ^{60}Co is about few PBq.

Industrial Accelerators Radiation Processing Facility (IARPF) operated in electron mode of energy ranging from 1.5 to 3 MeV are mainly used for cross-linking of polymers in cable industries. Such accelerators unlike radioactive sources, produces radiation only when they are energized. The RPF are of high radiation hazard potential.

(b) Research Accelerators

Research Accelerators or Particle Accelerator Research Facilities (PARF) are generally installed in academic & research institutions and catering to the research needs of various fields of high energy physics, material science, radiation studies etc. Accelerators installed in our country 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 very high-to-moderate. 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).

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

Gamma Irradiation Chamber is basically used for R&D 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. Now-a-days, X-ray based Irradiators are also used in blood banks and research application. X-ray energy ranges from 160 to 300 keV. They are of high-to-moderate radiation hazard potential.

(d) 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 medical cyclotron facilities are of high-to-moderate radiation hazard potential.

(e) Industrial Radiography (IR)

Radiography using Industrial Radiography Exposure Device (IRED), is one of the important non-destructive (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, the low energy X-ray ranges from 50 kV-450 kV and high energy X-ray from 4MV-15MV. IREDs are of high-to-moderate radiation hazard potential.

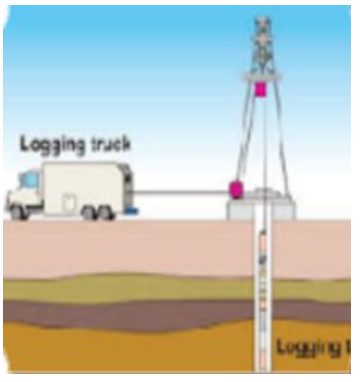
(f) Nucleonic Gauges (NG)

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 for nucleonic gauges 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. X-ray based gauges of energy in the range of 30 to 160 keV are also used in industries for coating thickness measurement. IRGDs are of moderate-to-low radiation hazard potential.

(g) Well Logging (WL)

Radioactive sources are used in well logging application for exploration of oil, coal and geophysical logging etc. The sources used are mainly ^{137}Cs for density measurement. The ^{241}Am-Be and Deuterium-Tritium generators (neutron generators) are used for exploration of hydrocarbon.

The activity ranges from kBq to GBq. They are of moderate-to-low radiation hazard potential.



2.2.3 Consumer Products, Scanning and Research Applications

(a) Consumer Goods Manufacturing Facilities

Consumer products such as smoke detectors, thorium gas mantles and starters, gaseous tritium luminescence devices use exempt quantity of radioactive sources. They are of very low hazard potential. However, regulatory control exists

on the manufacturing facilities of these devices. The products containing radioactivity above the exempt limits have to be assessed for safety and are required to be type approved by AERB.

(b) 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 either Linear Accelerators (LINAC) based or ^{60}Co isotope based. They contain high-to-moderate radiation hazard potential.

(c) 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 is carried out by AERB. Only the manufacturers/ suppliers of equipment are regulated.

(d) Facilities using Discrete, Sealed and Unsealed Sources

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

The details of accumulated Industrial Radiation Facilities/equipment and consents issued for various industrial facilities during the year 2021 are given in Table 2.16.

Table 2.16: Details of Consents issued for Industrial Radiation Facilities during the year

Type of Consent / Accumulated No. of Facilities / Equipment/Devices	RPF	Research Accelerators	Medical Cyclotron	GIC	IR	NG	WL
Accumulated No. of Facilities	23 (Gamma) & 13 (IARPF)	10	21	125	691	1,184	53
Equipment/Devices	24 Accelerators	10	21	129	3,212	8,525	1,670 (Sources)
Licence*	18	2	4	17	141	112	9
Type Approval/ Renewal Equipment	—	—	—		41	38	—
Sources	—	—	—	1	3	1	3
Permission for Import/ Procurement of Equipment	6	—	—	—	206	298	—

Permission for Procurement of Radioactive Sources	14	—	—	—	1,264	116	56
Approval (Layout/ Commissioning/ Source Storage Facility/D&C)	8	—	—	—	261	—	8

**Licence includes Licence/Authorisation/Registration for various Radiation Facilities.*

The details of accumulated Consumer Products and Scanning Facilities/equipment and consents issued for various consumer products and scanning facilities during the year 2021 are given in Table 2.17.

Table 2.17: Details of Consents issued for Consumer Products and Scanning Facilities during the year

Type of Consent / Accumulated No. of Facilities / Equipment/Devices	Consumer Goods Manufacturing Facilities	Container/ Baggage Scanner	Research Facilities (Sealed & Unsealed Sources)
	25	Container Scanner Facilities-20 Container Scanners-24	Sealed-354 Unsealed-192
Licence*	01	Container scanner-05 Baggage Scanner-323	80
Permission for Procurement of Radioactive Sources	—	—	262
Type Approval (Source & Equipment)	—	123	—

**Licence includes Licence/Authorisation/Registration for various Radiation Facilities.*

2.2.4 Approval of Radiological Safety Officers

While the built-in safety of the equipment and institution's operational preparedness towards safety are ensured by adhering to requirements specified by AERB in various regulatory safety documents, the implementation of radiation safety is carried out by Radiological Safety Officers (RSO). The RSOs thus not only act as extended arms of AERB at every radiation facility, but also play pivotal role between the radiation facility and the regulatory body.The number of RSO approvals/renewals issued for different practices during the year are as given in Table 2.18.

Table 2.18: Approval of Radiological Safety Officers in Radiation Facilities

Type of Practice	Number	Type of Practice	Number
Radiation Therapy	276	Radiation Processing Facilities/Gamma Irradiation Chamber (GIC)/ Medical Cyclotron (MCY)	54
Nuclear Medicine	239	Industrial Radiography	306
Diagnostic X-ray Facilities	2,285	Nucleonic Gauges & Well Logging	293
Research Centres	48	Consumer Product Manufacturer & Scanner Facilities	24

The maximum RSO Approvals were issued for Diagnostic Radiology Practice.

2.3 UNUSUAL OCCURRENCES/ ENFORCEMENT ACTIONS

(i) Work at Unauthorized Site by a Radiography Agency

A Mumbai based radiography agency was engaged in carrying out unauthorized radiography work at two sites in the state of Goa. In view of violations committed against the terms and conditions of Licence and taking cognizance of earlier violation by the same company, AERB suspended operation of all the industrial radiography devices and sealed all the radiography cameras in the centralized source storage facility of the institute on August 12, 2021, for a period of three months. Further, the RSO/Site-in-Charge, responsible for the site, was suspended to carry out Industrial Radiography work for a period of six months due to failure in performing his responsibilities.

(ii) Unauthorized Work on a Busy Road by a Radiography Agency

An Industrial Radiography agency was found carrying out unauthorized radiography work on a busy road in the day time at a place located in Mathura Highway, near Sarai Khatela, Uttar Pradesh using a Delta-880 radiography camera containing ~17 Ci (629 GBq) of ^{192}Ir source. Untrained person was found handling the radiography camera. The radiography camera was sealed by AERB Officers on the spot. In view of the violations, enforcement action was taken against the radiography agency on July 06, 2021 by suspending Licence for operations for a period of one year. Further, the RSO and radiographer responsible for the site were suspended to carry out industrial radiography work for period of one year, due to failure in performing their responsibilities.

(iii) Excessive Exposure to the Untrained Persons of an Industrial Radiography Supplier

There was an incident at an industrial radiography source supplier facility, which was revealed during investigation of exposure received by two untrained persons in excess of regulatory constraints. As an interim measure, AERB stopped granting new regulatory permissions to the source supplier till the corrective measures were implemented by the facility, which took around 2 months. Further, the RSO, responsible for the site, was suspended for a period of six months, due to failure in performing her responsibility.

(iv) Loss of Nucleonic Gauges with Sources

A Nucleonic Gauges institute was possessing 6 Nos. of unused ^{137}Cs sources 1.85 GBq each (~50 mCi). Though the sources were procured in 2012, these were not installed since then at their plant and were stored in a source storage room in the plant premises. The institute used to submit periodic safety status report (SSR) of the sources to AERB and last SSR was submitted in July 2021. The sources were under installation as per the report submitted in the SSR to AERB. On December 4, 2021, the institute found that all the 6 Nos. of Nucleonic Gauges sources were missing from its storage room and intimated the incident to DAE. The institute lodged a police complaint about the incident at the local police station. The missing sources could not be traced so far.

(v) Incidence of Source Stuck in an HDR-Brachytherapy Department

HDR Brachytherapy ^{60}Co source 37 GBq (1 Ci) was stuck due to the kink in the transfer tube during treatment, on July 06, 2021 of a hospital. The source could not be retracted back to the safe position manually. Hence, the patient was removed immediately and the room was locked. Subsequently, the service engineer was called and the service engineer transferred the source to the emergency container by cutting the source wire. The TLD records of the personnel involved in emergency handling did not show any significant dose.

2.4 INITIATIVES TOWARDS MAXIMUM GOVERNANCE, MINIMUM GOVERNMENT

(i) A circular was sent to Radiation Therapy and Nuclear Medicine Radiation Facilities on August 23, 2021 regarding the simplification of regulatory processes for radiation facilities. One of the frequent consents issued by AERB for procurement of equipment and source are now issued based on the electronic processing through e-LORA system. The process includes business validations. All the Radiation Therapy and Nuclear Medicine Radiation Facilities harness the benefit of receiving instant

approval of equipment and source procurement permissions subject to compliance with regulatory provisions.

(ii) Information was sent to all the stakeholders of Industrial Radiography practice on October 12, 2021, regarding the simplification of regulatory process w.r.t. engaging Radiation Professional (Site-in-Charge/Radiographer). The two-step process was modified to one step process, as a result of which it is easier for employer/licensee of industrial radiography facility for associating their employee in the e-LORA system.

2.4.1 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 disposed of once they reach the end of their useful life or 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.

During this year, 661 approvals were issued for export (towards repatriation) of radioactive sources to the country of origin, and 80 approvals were issued for returning the sources to the Indian supplier, for their safe management.

2.4.2 Safety Committees for Radiation Facilities

AERB has constituted several safety committees for multitier review based on hazard potential of radiation facilities. The safety committees review the radiation safety aspects of radiation facilities 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, medicine and academic institutions apart from the experts from BARC, BRIT and AERB. Number of meetings conducted by various committees for safety review of radiation facilities and transport of radioactive material during the year is as given in Table 2.19.

Table 2.19: Meetings of Safety Review Committees of Radiation Facilities

Name of Committee	Number of Meetings
Safety Review Committee for Applications of Radiation (SARCAR)	04
Committee on Safe Transport of Radioactive Material (COSTRAM)	01
Committee for Investigation and Review of Exposure in Nuclear Fuel Cycle and Radiation Facilities (CIRENURA)	03
Total	**08**

CHAPTER 3

REGULATORY INSPECTIONS

CHAPTER 3 - REGULATORY INSPECTIONS

3.1 REGULATORY INSPECTION PROGRAMME

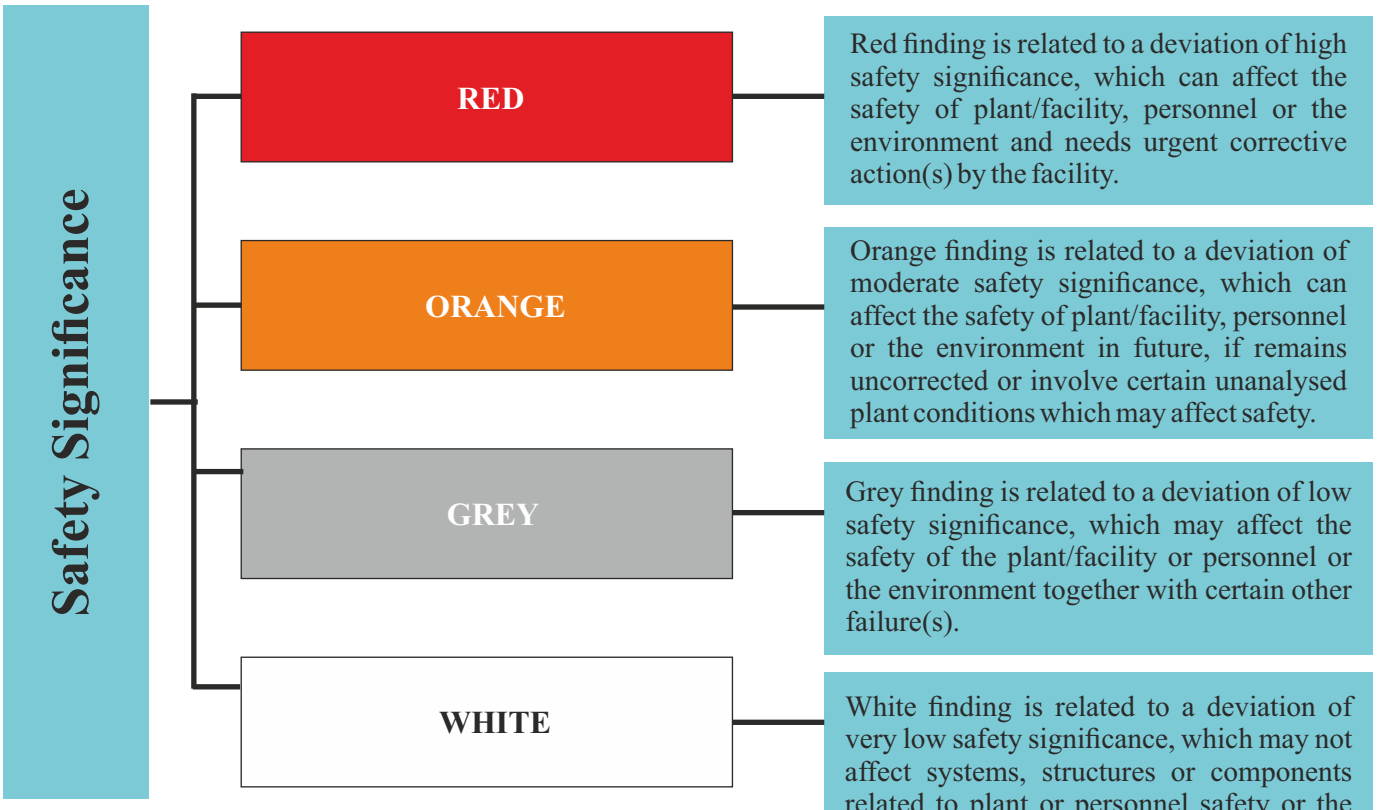
Regulatory Inspections (RI) is one of the key processes of AERB through which it is ensured that the activities performed by the Licensee during the life cycle of Nuclear, Industrial, and Radiation Facilities are executed in compliance with the conditions of the License and relevant safety requirements.

A comprehensive inspection programme is developed and implemented every year which provides an assurance that licensed activities are conducted in accordance with regulatory requirements and in conformity with safety and security objectives. The programme is developed using the graded approach and the frequency and the depth of regulatory inspections depend on the hazard potential of the facility and the consenting stage of the facility. Besides, inputs from previous inspection findings as well as safety review inputs 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.

After the onset of Covid-19 pandemic, AERB has developed a remote inspection process to continue its regulatory oversight over the licensed facilities and activities. During the year total 854 regulatory inspections of nuclear, industrial and radiation facilities were carried out. The details of regulatory inspections are provided in section 3.2.2.

The inspection report is also forwarded to the facility for improvement. The inspection findings made during the regulatory inspections are broadly categorised for follow up of their review and resolution. The facility is required to submit an action taken report on inspection findings within a specified timeframe. These action taken reports are reviewed in AERB for disposition and need for enforcement actions, if any.

AERB follows graded approach in determining the safety significance of the deviations observed during the regulatory inspection of the nuclear, industrial, 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 the implementation of all 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 of nuclear and industrial facilities are considered by AERB after review and acceptance of the corrective actions. The Licensee has its own internal mechanism for resolution of White findings, which is checked by AERB inspectors on sample basis during subsequent inspections.

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

AERB may also initiate enforcement action, if in its opinion, the licensee 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 regulatory inspection team can also initiate enforcement actions on-the-spot, if necessary, in case of serious non-conformances.

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

(a) A written directive for satisfactory rectification of the deficiency or deviation observed during inspection;

(b) Written directive to applicant/licensee for improvement within a reasonable timeframe;

(c) Orders to curtail or stop the activity;

(d) Modification, suspension or revocation of licence/consent; and

(e) Initiation of legal proceedings under provisions of the Atomic Energy Act, 1962.

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

3.2 REGULATORY INSPECTION OF NUCLEAR, INDUSTRIAL AND RADIATION FACILITIES

AERB carries out regulatory inspections of the nuclear, industrial and radiation facilities as a safety surveillance measure to ensure compliance with the AERB safety requirements and stipulations. In nuclear and industrial facilities, the emphasis is given to 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, industrial & fire safety, nuclear security, radiological monitoring and emergency preparedness.

AERB adopts a graded approach in conducting regulatory inspections. The number of planned inspections of a nuclear facility depends on its hazard potential and input received from other regulatory processes and may vary from 1 to 8 inspections in a year. The scope and depth of these inspections depends on the consenting stage of the facility and the activity at the site. In addition to these, additional inspections are conducted to gather information after important events or to observe specific activities.

AERB has posted onsite observers known as Site Observers Teams (SOT) at four NPP sites [Rawatbhata, Kalpakkam, Kakrapar and Kudankulam]. These SOT observe activities at the operating as well as under construction plants at these sites and submit report to AERB Headquarter (HQ) on daily basis, which provides important inputs for safety review and RIs. This has led to establishment of continuous regulatory presence at these sites, covering twelve operating, two under commissioning and five under construction NPPs. At other NPP sites, AERB conducts unannounced inspections, apart from routine announced inspections to observe the actual state of the facility and the way in which it is being operated and maintained.

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 from where periodic safety reports are not received (particularly inactive nucleonic gauge institutions) as per the specified requirements.

The regulatory inspections are carried out by AERB HQ located at Mumbai and its regional regulatory centres viz. the Southern Regional Regulatory Centre (SRRC), Chennai, Eastern Regional Regulatory Centre (ERRC), Kolkata and Northern Regional Regulatory Centre (NRRC), New Delhi. In addition, Directorate of Radiation Safety (DRS)/Radiation Safety Agency (RSA) in some of the States are also

authorized to carry out regulatory inspections for ensuring radiation safety of medical Diagnostic Radiology practices in respective States.

3.2.1 Remote Regulatory Inspection during COVID-19 Pandemic

The regulatory inspection programme faced a major challenge during the COVID-19 pandemic, which restricted the movement of people across the country. In view of these restrictions and the concern regarding safety & health of the inspectors, AERB developed an alternate process of remote regulatory inspections and continued its regulatory oversight over the licensed activities/facilities, as an interim measure till resumption of the routine physical inspections. This remote inspection involves,

(i) Assessment of the activity/facility by the utility itself as per the self-assessment checklists specially developed by AERB;

(ii) Review of self-assessment checklist by an inspection team for identifying the need for additional/supporting submissions (including records, documents, photographs, videos on sample basis) from the utility/facility;

(iii) Video conferencing with the licensee to verify certain compliances, as necessary; and

(iv) Issuance of inspection report after review of the evidences and submissions.

The self-assessment checklists developed for the remote regulatory inspections, in addition to various other checks to ensure safety also includes the checks done by the AERB inspectors at site during routine regulatory inspections. With the introduction of self-assessment by the licensee using checklists for various plant systems, functional areas and activities etc., responsibility for safety by the licensee gets reinforced and will certainly help in developing a better safety culture.

SOT deployed at NPP sites played at important role in remote regulatory inspections of facilities at respective sites. These officials checked the status of plant systems and the specific records, as identified by the other inspection team members at AERB, and provided required information for conducting the inspections.

3.2.2 Regulatory Inspections of Nuclear & Industrial Facilities (N&IF)

During the year, total 96 regulatory inspections (RI) of nuclear facilities (nuclear power projects, operating NPPs and fuel cycle facilities) and associated industrial facilities under the purview of AERB, were carried out covering safety (nuclear, radiological & industrial) and security aspects. Following Regulatory Special/Reactive Inspections were carried out on-site during the year:

(i) A reactive RI of RAPS-1&2 was carried out to investigate the incident of fall of a person in SFSB.

(ii) A reactive RI of MAPS-2 was carried out to investigate the incident of exposure of a radiation worker exceeding 15 mSv/year during ISI of moderator HX-1 in MAPS-2 BSD.

(iii) A Special RI of KAPP-3 was carried out to verify activities related to implementation of ECN for enhancement of cooling in high enthalpy area and to check adequacy of the up-gradations in insulation of feeder cabinet and PHT main system piping in KAPP-3.

(iv) A reactive RI of RAPS-6 was carried out to investigate the significant event of fire near PCP-2 at RAPS-6.

(v) RI of RAPS 1&2, RAPS-3 &4, RAPS-5& 6 and RAPCOFF were carried out for reviewing the radiological safety aspects.

(vi) A Special RI of KAPP-3 &4 was carried out to check aspects related to high temperature issue in RB areas of KAPP-3 and the related proposed modifications and their implementations in KAPP-3 & KAPP-4 (including radiological safety aspects).

(vii) A Special regulatory inspection of KAPP-4 carried out to verify the aspects related to structural steel beam modification at sample locations in KAPP-4.

The number of inspections conducted in Nuclear Facilities and associated industrial facilities is given in Table 3.20, 3.21 and 3.22.

Table 3.20: Regulatory Inspections of Nuclear Facilities (under Construction/Commissioning)

Project(s)	No. of Inspections	Project(s)	No. of Inspections
KKNPP-5&6	1	DFRP	2
KKNPP-3&4	2	NFC-Kota	1
KAPP-3&4	5	KGS-5&6	1
RAPP-7&8	2	GHAVP	1
PFBR	3		
Total Inspections			**18**

Table 3.21: Regulatory Inspections of Operating Nuclear Facilities

Facilities	No. of Inspections	Facilities	No. of Inspections
Operating NPP			
TAPS-1&2	3	NAPS-1&2	3
TAPS-3&4	3	KAPS-1&2	4
RAPS-1&2	4	KGS-1&2	2
RAPS-3&4	4	KGS-3&4	2
RAPS-5&6	6	KGS Site*	1
RR Site*	1	KKNPP-1&2	3
MAPS-1&2	5	KK Site*	1
IGCAR Facilities			
FBTR, KAMINI, IFSB	2	FRTG, RCL, RML	3
CORAL	2		
Total Inspections			**49**
** Inspection covering nuclear security aspects of whole site.*			

Table 3.22: Regulatory Inspections of Industrial and Fuel Cycle Facilities

Facilities	No. of Inspections	Facilities	No. of Inspections
HWP-Kota	1	UCIL-Turamdih Mine	1
HWP-Thal	1	UCIL-Turamdih Mill	2
HWP-Hazira	1	UCIL-Mohuldih Mine	1
HWP-Manuguru	1	UCIL-Bagjata Mine	1
HWP-Baroda	1	UCIL-Bhatin Mine	1
HWP-Talcher	1	UCIL-Narwapahar Mine	1
HWP-Tuticorin	1	UCIL-Banduhurang Mine	1
TDP- Chembur	1	UCIL- Tummalapalle Mine	1
NFC-Hyderabad	1	UCIL- Tummalapalle Mill	1
ZC- Hyderabad	1	IREL (India) Ltd., Udyogamandal	1
ECIL- Hyderabad	1	IREL (India) Ltd., OSCOM	1
ECIL- Tirupathi	1	IREL (India) Ltd., Manavalakurichi	1
UCIL-Jaduguda Mill	1	IREL (India) Ltd., Chavara	1
UCIL-Jaduguda Mine	1	KMML- Chavara	1
Total Regulatory Inspections			**29**

3.2.3 Regulatory Inspection of Radiation Facilities

The remote regulatory inspections in different types of radiation facilities carried out during the year 2021 are presented in the Table below. AERB conducted need-based physical inspections for type approval and pre-commissioning tests at radiation facilities. Besides, unannounced inspections at specific radiation facilities were also carried out by deputing inspectors from RRCs and HQ while adhering to all safety precautions and guidelines of Covid-19 pandemic.

Table 3.23: Regulatory Inspections of Radiation Facilities

Periodic Inspection			
Radiation Facility	**No. of Facilities/ Institutes Inspected**	**Radiation Facility**	**No. of Facilities/ Institutes Inspected**
Radiotherapy	129	Gamma Radiation Processing Facilities	12
Radiotherapy (Excessive Exposure)	2	Industrial Accelerator Radiation Processing Facility	9
Nuclear Medicine	95	Gamma Irradiation Chamber	53
Nuclear Medicine (Excessive Exposure)	7	Industrial Radiography	183
Diagnostic Radiology	122	Industrial Radiography (Excessive Exposure)	18
Diagnostic Radiology (Excessive Exposure)	41	Industrial Radiography Supplier	1
Medical Cyclotron	4	Well Logging	11
PARF	3	Nucleonic Gauges	2
Calibration	4		
Type Approval			
Diagnostic Radiology, X-ray Baggage, Consumer Products			35
Consent (Siting, Pre-commissioning, Commissioning, Permission to Operate, Renewal of License)			
Radiation Processing Facilities, Medical Cyclotron, Container Scanner			12
Special/Reactive/Complained Based/DR QA Tool Verification			
Radiotherapy, Nuclear Medicine, Diagnostic Radiology, Medical Cyclotron			15
Total Regulatory Inspections			**758**

CHAPTER 4

ENVIRONMENTAL SAFETY AND OCCUPATIONAL EXPOSURES

CHAPTER 4 - ENVIRONMENTAL SAFETY AND OCCUPATIONAL EXPOSURES

4.1 ENVIRONMENTAL SAFETY

Environmental safety in the vicinity of nuclear installations is ensured through control on radioactive discharges into the environment and environmental monitoring. These radioactive discharges are mainly in the form of liquid and gaseous radioactive effluents released during the operation of the facility.

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

AERB has 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 Safety Code deals with the requirements for radiation protection aspects in design, construction and operation of waste management facilities and the responsibilities of different agencies involved. The Code is also applicable to the management of radioactive waste containing chemically and biologically hazardous substances, even though other specific requirements may additionally be applicable as per relevant standards.

AERB has specified that the radiation dose to the members of public near the operating NPPs due to the discharges from the plants shall not exceed annual limit of 1 mSv (i.e. 1000 micro-Sievert). This is in line with the limits recommended by International Commission on Radiological Protection (ICRP). Based on this limit, AERB has further specified limits on effluent discharges through gaseous and liquid routes in the Technical Specifications for operation of NPPs. These technical specification limits are set far below the dose apportionment to the public for the specific radionuclide. The radionuclide specific dose apportionment is small fraction of the annual dose limit (1000 micro-Sievert) to the public. While specifying these limits, it is ensured that the discharge is controlled within public exposure limit following the principles of "As Low as Reasonably Achievable" (ALARA). The limits specified in the technical specifications actually ensure that the dose to the public is well below the specified limit of 1000 micro-Sievert for any NPP Site. In general, the actual discharges from the plants are observed to be much below the limits specified.

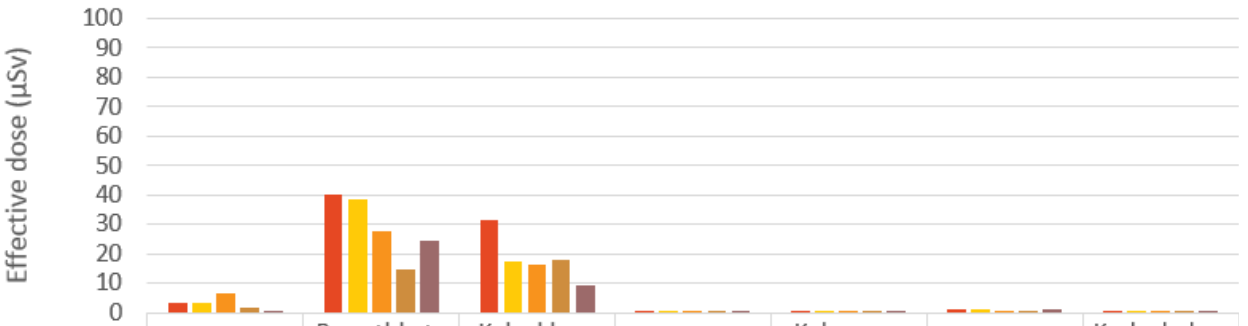
It is seen that the effective dose to public around all NPP sites is far less than the annual limit of 1mSv (1000 micro-Sievert) prescribed by AERB.

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 (ESL) 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 2021 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 less than 5% of annual limit of 1mSv (1000 micro-Sievert) prescribed by AERB.

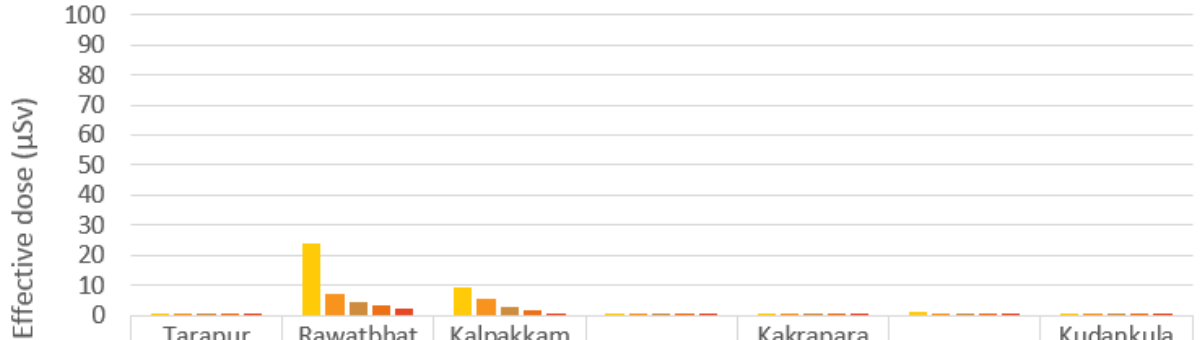
The effective doses to the members of the public (hypothetical person from Year 2017 to 2021) due to the release of radioactive effluents from the plants are presented in the Figures 4.1 (a) and 4.1 (b).



	Tarapur Site	Rawatbhata site	Kalpakkam site	Narora Site	Kakrapara Site	Kaiga Site	Kudankulam site
2017	3.41	40.21	31.20	0.37	0.22	1.30	0.012
2018	3.16	38.30	17.51	0.30	0.19	0.89	0.005
2019	6.52	27.72	16.39	0.48	0.25	0.60	0.004
2020	1.57	14.55	18.00	0.43	0.48	0.64	0.0096
2021	0.235	24.14	9.38	0.51	0.21	0.97	0.0027

Figure 4.1(a): The public dose to a hypothetical person from Year 2017 to 2021 at site boundary.

Note: 1. Public dose at Rawatbhata and Kalpakkam sites are relatively higher as compared to other reactor sites due to release of ^{41}Ar from RAPS-2 and MAPS.
2. Radioactive effluent releases from NPPs were within specified annual limits of 1000 (µSv)



	Tarapur Site	Rawatbhata Site	Kalpakkam Site	Narora Site	Kakrapara Site	Kaiga Site	Kudankulam Site
1.6km	0.235	24.14	9.38	0.51	0.21	0.97	0.0027
1.6-5km	0.068	7.33	5.70	0.35	0.14	0.72	0.00094
5-10km	0.066	4.35	2.73	0.30	0.12	0.54	0.00037
10-15km	0.053	3.36	1.56	0.24	0.10	0.32	0.00022
15-30km	0.0175	2.00	0.69	0.20	0.09	0.46	0.00015

Figure 4.1(b): The public dose to the hypothetical person at site boundary due to the release of radioactive effluents from NPPs.

Note: 1. Public dose at Rawatbhata and Kalpakkam sites are relatively higher as compared to other reactor sites due to release of ^{41}Ar from RAPS-2 and MAPS.
2. Radioactive effluent releases from NPPs were within specified annual limits of 1000 (µSv)

4.2 OCCUPATIONAL EXPOSURES

In each NPP and 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 surveillance and safety support functions. These include radiological monitoring of workplace, plant systems, personnel, effluent monitoring, carrying out exposure control, exposure investigations, and analysis & trending of radioactivity in plant systems.

All NPPs & FCFs have established radiological surveillance programme and work procedures intended to control the occupational exposures. AERB Safety Manual on 'Radiation Protection for Nuclear Facilities' (AERB/NF/SM/O-2 (Rev.4), 2005) specifies Dose Limits and Investigation Levels (IL) for occupational radiation workers to control the individual doses. As per AERB Directives, for an occupational radiation worker, annual dose limit is 30 mSv, with the condition that it should not exceed 100 mSv in a span of 5 years. The specified annual dose 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 number of workers in NPPs and Fuel Cycle Facilities who received dose below and above 20 mSv during the year 2021 is given in Table 4.24 and 4.25 respectively. In the year 2021, there was no case of individual radiation exposure above the prescribed annual dose limit of 30 mSv. Figure 4.2 gives collective dose (Person-Sv) for operation and maintenance of NPPs for last 5 years.

Table 4.24: Radiation Doses Received by Workers in Nuclear Power Plants (2021)

NPPs	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	830	1.28	581	1.83	830	0
RAPS-1&2	959	2.08	817	2.44	959	0
MAPS-1&2	1,048	2.51	941	2.79	1,048	0
NAPS-1&2	1,218	1.25	923	1.65	1,218	0
KAPS-1&2	1,120	1.72	871	2.22	1,120	0
KGS-1&2	1,308	1.60	1,079	1.94	1,308	0
RAPS-3&4	1,158	0.98	804	1.41	1,158	0
TAPS-3&4	1,258	1.43	953	1.89	1,258	0
KGS-3&4	1,045	0.41	683	0.63	1,045	0
RAPS-5&6	1,265	1.02	963	1.34	1,265	0
KKNPP-1&2	2,000	0.44	679	1.29	2,000	0
KAPP-3&4	1,612	0.35	406	1.39	1,612	0
Total	14,821	---	9,700	---	14,821	0

**KAPP-3 achieved first criticality on July 22, 2020.*

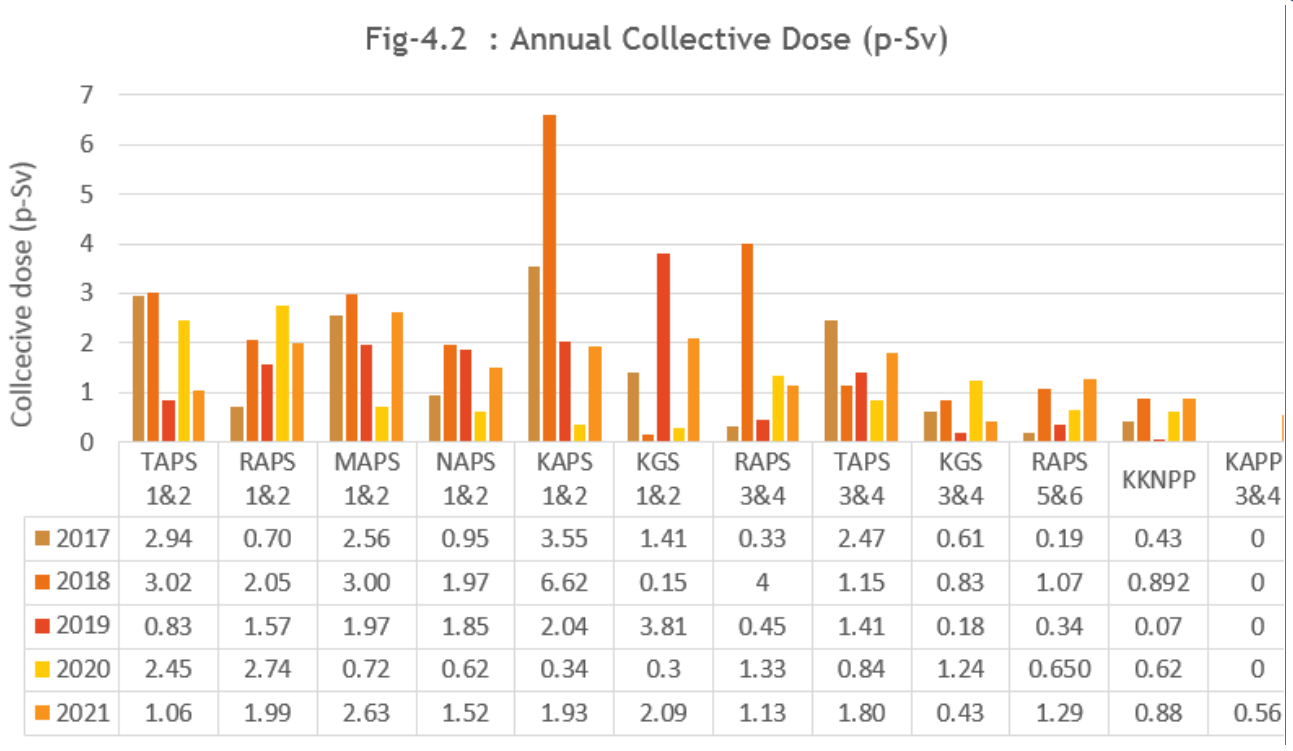


Fig 4.2 Collective Dose (Person-Sv) at NPPs
Note : KAPP-3 achieved first criticality on July 22, 2020

Table 4.25: Radiation Doses Received by Workers in Front End Fuel Cycle Facilities (2021)

Type of facilities	Location	Number of Persons Received Dose	Average Dose Among Dose Receivers (mSv) (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	708	4.34	7.96	708	Nil	Nil
	Bhatin	21	2.24	1.04	21	Nil	Nil
	Narwapahar	811	3.6	5.93	811	Nil	Nil
	Bagjata	391	2.56	5.29	391	Nil	Nil
	Banduhurang	368	2.29	3.45	368	Nil	Nil
	Mohuldih	317	3.84	6.15	317	Nil	Nil
	Turamdih	555	3.44	5.73	555	Nil	Nil
	Tummalapalle	1,641	4.58	8.91	1,641	Nil	Nil
Uranium Mill (UCIL)	Jaduguda	1,124	2.04	4.70	1,124	Nil	Nil
	Turamdih	749	2.03	4.60	749	Nil	Nil
	Tummalapalle	760	0.46	1.33	760	Nil	Nil
Thorium Mines and Mills. IREL (India) Ltd.	Chavara	60	0.29	4.60	60	Nil	Nil
	Manavalakurichi	122	1.3	10.82	122	Nil	Nil
	Udyogamandal	211	0.66	5.51	211	Nil	Nil
	OSCOM	472	3.7	21.14	471	1	Nil
Fuel Fab. (NFC)	Hyderabad	1,205	0.77	8.30	1,205	Nil	Nil
	Total	9,515	2.70	21.14	9,514	1	Nil

4.2.1 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 investigations and analysis etc.

During 2020, total 16 radiation workers in diagnostic radiology (X-ray) 13, and 3 workers in Industrial Radiography were received radiation dose between 20 to 30 mSv due to non-standard operating practice. While, during 2021, total 29 radiation workers in diagnostic radiology (X-ray) 22, and 3 workers in Industrial Radiography and 4 workers in Nuclear Medicine were received radiation dose between 20 to 30 mSv due to non-standard operating practice. The radiation doses received by workers in Medical, Industrial and Research institutions for years 2020 and 2021 are given in table 4.26 and 4.27 respectively.

Table 4.26: Radiation Doses Received by Workers in Medical, Industrial and Research Institutions (2020)

Category of Radiation Worker	No. of Monitored Persons	Average Dose for Monitored Persons (mSv)	No. of Persons Receiving 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 (2015 to 2019)
					0<D ≤20	20<D ≤30	30<D ≤50	D>50	
Diagnostic X-rays	1,34,873	0.21	36,870	0.76	36,856	13	1	0	19
Radiation Therapy	15,864	0.10	3,532	0.45	3,532	0	0	0	0
Nuclear Medicine	2,546	0.36	1,135	0.81	1,135	0	0	0	1
Industrial Radiography	7,452	0.35	1,975	1.33	1,971	3	0	1	9
Radiation Processing Facility	140	0.04	14	0.38	14	0	0	0	0
Research	4,320	0.10	864	0.51	864	0	0	0	0
Total	1,65,195	0.20	44,390	0.76	44,372	16	1	1	29

As per AERB Directives, for an occupational worker, annual dose limit is 30 mSv, with the condition that it should not exceed 100 mSv in a span of 5 years. 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.

Table 4.27: Radiation Doses Received by Workers in Medical, Industrial and Research Institutions (2021)

Category of Radiation Worker	No. of Monitored Persons	Average Dose for Monitored Persons (mSv)	No. of Persons Receiving 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 (2015 to 2019)
					0<D ≤20	20<D ≤30	30<D ≤50	D>50	
Diagnostic X-rays	1,41,764	0.23	40,221	0.80	40,198	22	1	0	14
Radiation Therapy	15,473	0.12	3,519	0.52	3,519	0	0	0	0
Nuclear Medicine	2,678	0.45	1,172	1.02	1,168	4	0	0	0
Industrial Radiography	8,092	0.33	1,779	1.52	1,774	3	2	0	7
Radiation Processing Facility	148	0.02	16	0.14	16	0	0	0	0
Research	3,918	0.08	887	0.34	887	0	0	0	0
Total	1,72,073	0.22	47,594	0.80	47,562	29	3	0	21

**Data (External dose) as on April 25, 2022 with National Occupational Dose Registry System (NODRS). The data does not include excessive exposure cases above investigation levels which are currently under investigation.*

4.3 BASIS FOR ACCEPTABLE DOSE TO OCCUPATIONAL WORKERS AND ENVIRONMENTAL RELEASES

The dose limits for exposure from ionizing radiation for occupational workers and the members of the public are prescribed by AERB in its Directive No. 01/2011 under Rule 15 of the Atomic Energy (Radiation Protection) Rules, 2004. These dose limits are based on the ICRP recommendations and IAEA Safety Standards on Radiological Protection and are in line with the international practice and standards.

The estimated dose to the members of the public due to discharge of radioactive effluents from nuclear facilities at a site shall not exceed an effective dose of 1 mSv in a year.

(i) 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.

(ii) Authorised Limits of Environmental Releases/ Discharge

The discharge of radioactive waste from licensed facilities is governed by the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987. It is mandatory for each licensed 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 discharge.

Discharge constraints are set at a much lower value than the authorized limits to achieve effluent releases at ALARA level. These discharge constraints are usually set at 50-65% of authorized discharge limits taking into cognizance the differences in NPP system designs. The operating data shows that releases from NPPs have been a small fraction of the specified release limits.

4.4 INITIATIVES TAKEN BY AERB FOR DOSE REDUCTION

(i) Review of Radiation Protection Aspects during Project Stage

During design and commissioning stages, it is ensured that an elaborate radiation monitoring system consisting of area radiation monitors, process monitors, environmental monitors and effluent monitors is made available to give history, trend and instantaneous readings of the monitors for exposure control. Based on the operating experience, many design modifications for exposure control have been incorporated progressively in the Indian NPPs.

During the year 2021, detailed review and analysis of radiological status and collective dose was done on the aspect of achieving stable operation of KAPP-3.

(ii) Operation Phase

Radiation protection programme during the operation of facility is periodically revised by the facilities which is subsequently 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 ensures that plant management makes adequate review of the implementation and the effectiveness of the radiation protection programme. RSO for each Nuclear Facility is authorized by AERB to carry 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 ensure that effluent releases and public exposures are below the regulatory limits.

(iii) Collective Radiation Dose Budgeting

Collective Dose Budget (CDB) is prepared by each facility annually on the basis of jobs (related to radiation) 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 lapses in previous attempt of jobs and corrective actions taken etc. The aim is to optimize the CDB 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.

(iv) Review of Radiological Safety Aspects

Routine quarterly and annual reports on radiological safety aspects are prepared by the RSO of the facility and submitted to AERB periodically. 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.

(v) Regulatory Inspections

During the regulatory inspection, radiological aspects of NFs operation are reviewed. This includes radiological status of the plant, individual and collective dose, effluent discharges, radioactive waste management, environmental monitoring, adherence to radiation protection procedures by workers, safety culture and quality assurance programme in radiation protection etc. Additionally, AERB also conducts regulatory inspections during Biennial Shutdown (BSD)/Refuelling Shutdown (RSD) of NPPs to ascertain compliance with radiation protection requirements. Any deviation from established procedure is reported in inspection report. These issues are then deliberated in AERB and Stations are asked to address them suitably.

During the year 2021, physical regulatory inspections could not be carried out because of travel restrictions due to COVID-19 pandemic preventive measures. However, review work continued through Remote Regulatory Inspections (RRI). In the later part of the year partial physical regulatory inspections were

done and some of the inspections were conducted in hybrid mode also.

(vi) Review of Radiation Exposure to Occupational Workers

The radiation exposure to the occupational workers is periodically reviewed by AERB based on the Health Physics reports. The exposure cases exceeding the regulatory constraints/limits are primarily investigated by the exposure investigation committee at each facility. These investigation reports are then reviewed by AERB for appropriateness of investigation and suitable corrective actions.

(vii) 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:

(a) 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 implement corrective actions.

(b) 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 Station personnel.

(c) Improved collective dose budgeting.

(d) Restricting the external exposure by means of shielding, remote operation, source control, rehearsing the work on mock-ups and minimizing the exposure time.

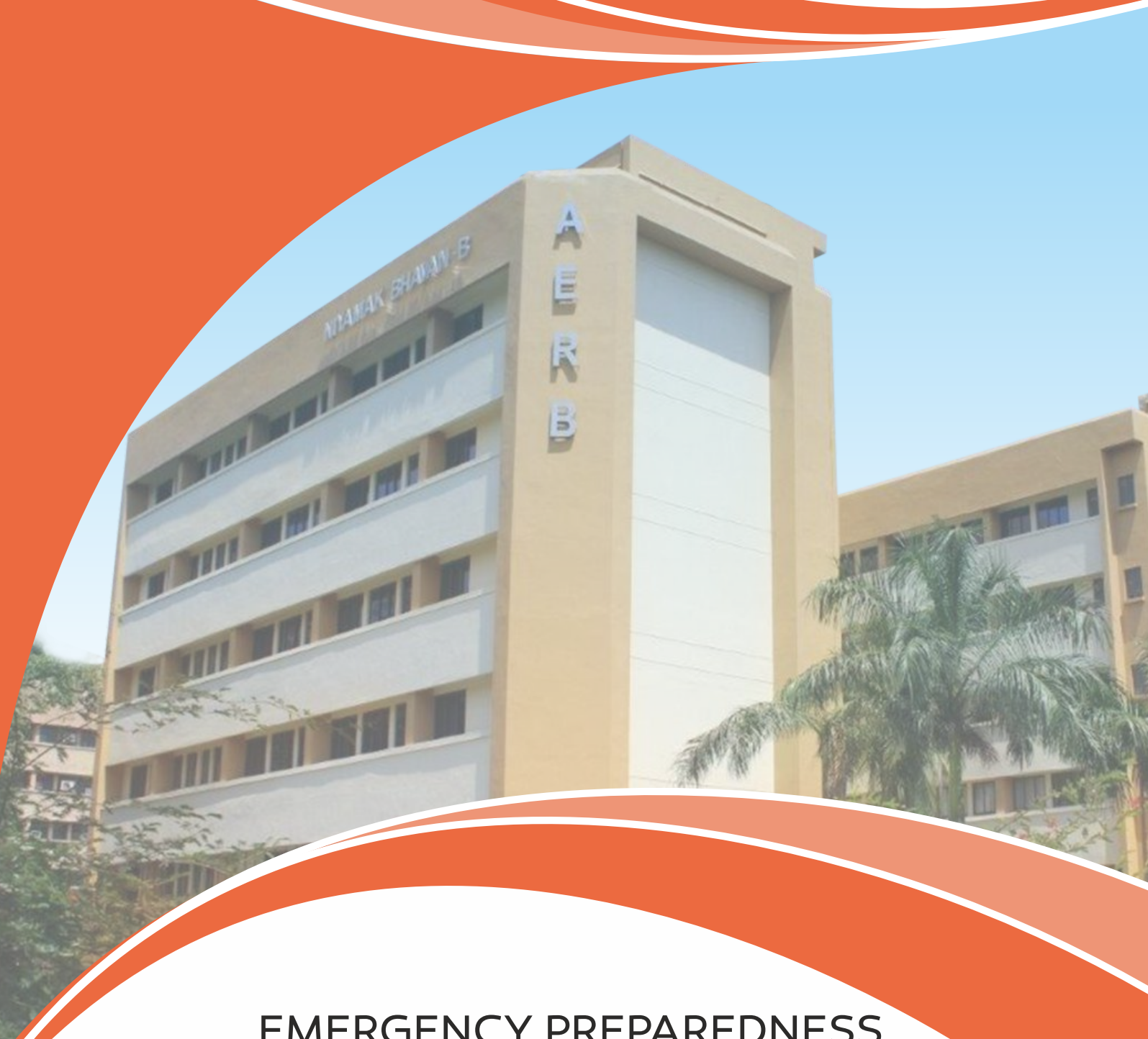
(e) Minimizing the internal exposures by source control.

(f) Periodic review of radioactive work practices.

(g) Periodic training of radiation workers on radiation protection aspects, and

(h) Trending and analysis of radiological data.

CHAPTER 5



EMERGENCY PREPAREDNESS

CHAPTER 5 - EMERGENCY PREPAREDNESS

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

Similarly, EPR plans are ensured for non-nuclear facilities that are under the purview of AERB and handling hazardous chemicals viz. ammonia and hydrogen sulphide based Heavy Water Plants (HWP) and some of heavy water plants catering to the production of solvents. These 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 radiation facilities (RF) also.

5.1 ROLE OF AERB IN EMERGENCY PREPAREDNESS AND RESPONSE

AERB has established regulations and guidelines specifying the principles, requirements and associated guidance and criteria for emergency preparedness and response. 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 approving the EPR plan of the licensee. AERB oversees 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 situation, review of response actions and inform public as and when necessary.

5.2 REVIEW OF PREPAREDNESS FOR EMERGENCY AT NPP SITES

The various type of Emergency conditions at nuclear facilities are elaborated below:

Plant Emergency	Declared emergency conditions in which the radiological/other consequences, confined to the plant or a section of the plant, requiring immediate operator action.
Site Emergency	Accidental condition/emergency situation in the plant involving radioactivity transgressing the plant boundary but confined to the site, or involving release of hazardous chemicals or explosion, whose effects are confined to the site, with off-site consequences being negligible.
Off-Site Emergency	Accident condition/emergency situation involving excessive release of radioactive materials/hazardous chemicals from the plant to the public domain calling for intervention.

AERB reviews the preparedness of NPPs to handle these emergency conditions through review of EPR plans, conduct of regulatory inspection and observation of emergency exercise following a graded approach.

During the year, NPPs continued to conduct emergency exercises. Plant Emergency Exercise (PEE) and Site Emergency Exercise (SEE) were carried out as per schedule. The conduct of Off-site emergency exercise with participation of District Authorities resumed at Sites where the exercise had to be postponed due to Covid-19 related restrictions and precaution of District officials in Covid-19 response measures.

PEE and SEE are conducted by Stations with the frequencies once in every quarter and once in a year respectively. Currently OSEE is carried out with a frequency of once in two years.

The OSEE framework has been strengthened through conduct of different type of exercises, namely the Table-Top (TT) exercise and Integrated Command Control and Response (ICCR) OSEE.

In the TT exercises, the emphasis is on testing the decision-making capability of plant authorities on aspects such as classification, declaration, notification and evolving protection strategy based on plant conditions for recommending protective actions.

In the ICCR OSEE procedure, in addition to the decision-making process by plant authorities, the aspects of testing command control functions, early warning and field response along with resource mobilization in realistic environment, inter-agency co-ordination, communication, etc., are being tested. The ICCR procedure involves activation of the overall response framework covering Plant Authorities, District Authorities, CMG-DAE & DAE-RERD. As an important feature these exercises are conducted in a realistic environment where, the information on the event and possible consequence are not known to the response organizations participating in the exercise.

During year, the ICCR, OSEE was conducted at four NPP sites viz. Tarapur, Narora, Kudankulam and Kalpakkam Sites. The number of SEE and OSEE conducted at various NPP Sites in 2021 are listed in Table 5.28.

Table 5.28: Site and Off-site Emergency Excises at NPPs (2021)

NPP Sites	SEE	OSEE (ICCR)	NPP Sites	SEE	OSEE (ICCR)
Tarapur	1	1	Kakrapar	1	1
Rawatbhata	1	-	Kaiga	1	-
Kalpakkam	1	-	Kudankulam	1	1
Narora	1	1			
Total	**SEE- 07**		**Total**	**OSEE (ICCR) - 04**	

Functioning of Site Emergency Control Centre (SECC) during ICCR Off-Site Emergency Exercise at Kudankulam Site

Field Monitoring during ICCR Off-Site Emergency Exercise at Tarapur Site

Functioning of District Emergency Operation Centre (DEOC) during ICCR Off-site Emergency Exercise at Kalpakkam Site

Feedback Meeting after ICCR offsite Emergency Exercise at NAPS Site

Monitoring for ICCR Off-site Emergency Exercise from NREMC

AERB officials participated as observers during the exercises. Decision making capabilities and response actions by plant and District Authorities were observed. Nuclear and Radiological Emergency Monitoring Centre (NREMC) was also activated and progression of event and response actions were monitored and assessed. Observations and findings were noted by all the Stakeholders and these were discussed in the feedback meeting after the completion of the exercise for further improvements.

5.3 STRENGTHENING OF EMERGENCY PREPAREDNESS PLANS OF NPPs

The preparedness for response during any emergency conditions emanating in NPPs are being strengthened. This is carried out through augmenting the arrangement and updating the emergency preparedness and response (EPR) plans considering various developments (technical basis, feedback from Fukushima event, IAEA and ICRP publications) and in accordance to the current regulatory requirements.

As part of this, NPPs are advised to revise the EPR plans for managing Plant, Site and Off-site emergency responses based on the template approved by AERB and various supporting/guidance documents developed by AERB expert group. The revision of plans considered the following.

- Changes in emergency response organization and notification to other response agencies in line with the revised response framework established in the revised off-site ERP plan
- Harmonized approach and criteria for activation of various emergency response centres
- Plant specific ICs and EALs for classification and declaration of emergency
- Integration of EOP and SAMG that are part of accident management programme with the emergency response plans

5.4 CREATION OF ON-SITE EMERGENCY SUPPORT CENTRE AT NPPs

Based on the reviews undertaken during safety assessments of Indian NPPs, in light of the accident at Fukushima NPPs, AERB mandated the requirement for establishing the On-Site Emergency Support Centre (OESC) at all NPP sites. AERB constituted an Advisory Committee to develop the guidelines for establishing OESC at all NPP Sites. This facility will

have capability to withstand earthquake and flood of magnitudes larger than their respective design basis for the NPP. The building will be designed with requisite shielding for protected stay of response personnel for extended duration. AERB, after a detailed review, accepted the generic guidelines prepared by the Advisory Committee for establishing OESC and had asked NPCIL to submit design basis report for the site specific OESC for all NPP sites in accordance with these guidelines. The design of OESC has been finalized by the utilities and the implementation is in progress.

5.5 DECISION SUPPORT SYSTEM

Decision Support System (DSS) for handling nuclear emergencies is intended to provide comprehensive and timely information to emergency managers on an emergency situation arising from a nuclear accident. Based on the radiological monitoring readings of installed radiation monitors at NPPs and meteorological conditions, the DSS identifies affected sector and estimates the projected public dose. These estimates are used to decide appropriate protective actions in the public domain. Implementation work on DSS is in progress at all the NPP Sites.

5.6 NUCLEAR AND RADIOLOGICAL EMERGENCY MONITORING CENTRE

During nuclear and radiological emergency, AERB monitors keep itself informed about the emergency situation. It reviews & assesses the emergency situation, and if required, provides appropriate regulatory support and advice to the relevant response agencies. AERB also informs the public and the Government on the safety significance of events and actions being taken. To facilitate this, AERB has instituted an Emergency Response Monitoring Organization (AERB-ERMO) which gets activated during an emergency. The activities of AERB-ERMO is carried out and coordinated by the Nuclear and Radiological Emergency Monitoring Center (NREMC) established at AERB. The Centre is equipped with various cells (Communication, Assessment, Analysis & Legal) along with necessary software and hardware infrastructure.

The capabilities of NREMC includes, emergency analysis, assessment of emergency response actions & protective actions and communication with all Stakeholders. The 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 has 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 functions are tested including independent assessment. In case of real emergencies, NREMC is activated as per the established procedures.

During the year, remote observation of off-site emergency exercise was also conducted from NREMC with use of its state of the art video visual systems. This will ensure business continuity even under situations having travel restrictions limiting the on-site observation by AERB observer teams.

5.7 DEVELOPMENT OF REGULATORY DOCUMENTS RELATED TO EMERGENCY MANAGEMENT

As a step towards holistic revision, the existing requirements are being consolidated/updated through a safety code and safety guides for management of the nuclear and radiological emergencies. The code and guides for emergency preparedness and response are being developed taking into account existing EPR requirements, developments including the change in the approach to public protection during emergency conditions as elaborated in ICRP publications, IAEA general safety requirements, lessons learned from the Fukushima accident and subsequent safety review of Indian nuclear power plants (NPPs). The revision also takes account of current NDMA guidelines, enhancements in emergency exercise methodology and the importance of early phase decision making.

As per the AERB regulatory document process on EPR, the requirements and guidance are presented through a Safety Code and three specific guidance documents for nuclear facilities, radiation facilities and transport of radioactive material.

These documents are being prepared following a bottom to top approach that uses the outcomes of developmental activities and supporting technical documents developed by AERB for deriving its requirements and guidance.

The new safety Code and Guides on EPR are under various stages of preparation, review and publication.

CHAPTER 6

REGULATORY SAFETY DOCUMENTS

CHAPTER 6 - REGULATORY SAFETY DOCUMENTS

One of the core activities of AERB is to develop the safety regulation for stakeholders. Development and revision of Regulatory Safety Documents (REGDOCs) is a continual process of AERB to keep itself updated in line with international recommendations and good practices. Through this process, the existing regulatory documents are taken up for revision and additional regulatory documents are also taken up for development. Accordingly, AERB has put in place a process for development/revision of Regulatory Safety Documents (REGDOCs). The process takes into account the following aspects:

(I) Outcome of Safety reviews/Legal reviews/ technical discussions

(ii) Requirements identified during Licensing or Enforcement of Regulations

(iii) New regulatory and technological developments relevant to AERB

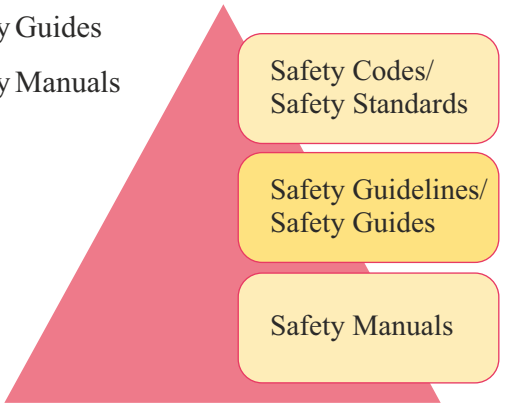
(iv) International practices and requirements

(v) Experience/Feedback from Nuclear, Radiation and other R&D Facilities

The framework for regulatory document development involves a multi-tier review system. The experts from AERB, Technical Support Organisations (TSO), National R&D Centres, Industries, Academic Institutes, other Government Organisations, and retired specialists having experience in the related fields are involved in the development process as appropriate.

Regulatory safety documents are classified as follows in descending order of hierarchy:

- Safety Codes and Standards
- Safety Guides
- Safety Manuals



The requirements covered in Safety Codes, Safety Standards and Safety Guidelines are mandatory in nature. Safety Guide contains guidance to meet the requirements specified in the Safety Codes and Standards and Safety Manuals contain detailed methodologies. Safety guides and Safety Manuals are recommendatory in nature.

6.1 REGULATORY SAFETY DOCUMENTS DEVELOPMENT PROCESS

AERB has well established process for development, review, and revision of REGDOCs. Experts, utility and stakeholders are involved in the development of the regulations and guides by direct involvement as well as through comments and feedback throughout the development process. Technological advances, research and development work, relevant operational lessons learned and institutional knowledge are considered as appropriate in development/ revision of the REGDOCs.

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

AERB has issued regulations and safety documents which provide adequate coverage commensurate with the radiation risks associated with the facilities and activities, in accordance with a graded approach. Till date, AERB has published 152 regulatory safety documents which include Safety Codes, Standards, Guidelines, Guides and Manuals. The progress on REGDOCs during the year is given in the next section.

6.2 REGULATORY SAFETY DOCUMENTS DEVELOPED/AMENDED

The following Safety Guide has been published by AERB in the year 2021:

Safety Guide on "Regulatory Control of Radioactive Discharges to the Environment" [AERB/NRF/SG/RW-10]. This safety guide provides guidance for regulatory control of radioactive discharges to the environment and

disposal of solid waste from Facilities and Activities for planned exposure situation.

The guide provides harmonised, structured and graded approach for authorisation of waste discharge/disposal considering optimisation of protection and safety guidance for implementation of waste discharge/disposal authorisation to ensure compliance with the safety requirements.

This safety guide also provides guidance regarding disposal of waste from radioactive consumer products. It is applicable for nuclear installations including mining and processing of ores for the extraction of uranium or thorium as part of the nuclear fuel cycle programme and the applications of radioisotopes in industry, medicine, agriculture and research. This safety guide is applicable for new, existing and modified facilities/activities or for the review of an established waste discharge/disposal authorization.

6.3 SAFETY DOCUMENTS UNDER REVISION/DEVELOPMENT

REGDOCs on different topics are being developed or being revised in accordance with established process. The R0 drafts of the following regulatory safety documents were prepared:

1) Safety Guide on 'Management of Nuclear and Radiological Emergency in Nuclear Facilities' (AERB/SG/NRE-1)
2) Safety Guide on 'Deterministic Safety Analysis for Sodium Cooled Fast Reactor based NPPs' (AERB/NPP-SFR/SG/D-19)
3) Safety Guide on 'Design of I&C Systems for NPPs' [AERB/SG/D-25 (REV. 1)]
4) Safety Guide on 'Radiation Protection Aspects in Design of NPPs' [AERB/NPP/SG/D-12 (Rev.1)]
5) Safety Guide on 'Management of Emergency during Transport of Radioactive Material' [AERB/NRF/SG/NRE-3]
6) Safety Guide on 'Consumer Products' [AERB/RF/SG/CP]
7) Safety Guide on Management of Radioactive Wastes Arising from Nuclear Medicine Facilities [AERB/RF/SM/RW-1]
8) Safety Guide on Containment Systems Design for NPPs [AERB/SG/D-21 (REV. 1)]
9) Safety Guide on 'X-ray Generating Equipment Used For Research, Education, Inspection And Analysis' [AERB/RF/SG/XREIA]
10) Safety Manual on 'Radiation Protection in NFC Facilities' (AERB/NF/SM/O-2)
11) AERB Safety Glossary (AERB/SG/GLO).

The following draft regulatory safety documents are under subsequent stages:

1) Safety Code on Radiation Sources, Equipment and Installations (AERB/RF/SC)
2) Safety Code on 'Management of Nuclear and Radiological Emergency' (AERB/NRF/SC/NRE)
3) Safety Code on 'Management of Safety in Nuclear Facilities' (AERB/NF/SC/MS)
4) Safety Code on Regulation of Nuclear and Radiation Facilities [AERB/NRF/SC/G (REV. 1)]
5) Safety Code on Design of Sodium Cooled Fast Reactor based NPPs [AERB/NPP-SFR/SC/D]
6) Safety Standard on 'Civil Engineering Structures Important to Safety of NFs' (AERB/SS/CSE (Rev. 1)
7) Safety Guide on 'Seismic Studies and Design Basis Ground Motion for NPP Site' (AERB/SG/S-11 Rev. 1)
8) Safety Guide on 'Deterministic Safety Analysis for Water Cooled Reactor based NPPs' (AERB/NPP-WCR/SG/D-19)
9) Safety Guide 0n Commissioning of Sodium Cooled Fast Reactor Based NPPs [AERB/SG/O-4D]
10) Safety Guide on 'Industrial Radiography' (AERB/RF/SG/IR)
11) Safety Guide on 'Container Scanner' (AERB/RF/SG/CS)
12) Safety Guide on 'Industrial Accelerator Radiation Processing Facilities' (AERB/RF/SG/IARPF)
13) Safety Guide on 'Manufacture, supply and use of medical diagnostic X-ray equipment' (AERB/RF/SG/DR)

14) Safety Guide on 'Medical Cyclotron Facilities' [AERB/RF/SG/MCF(Rev.1)]

15) Safety Guide on 'Radiation Therapy' (AERB/RF/SG/RT)

16) Safety Guide on 'Design of Fuel Handling and Storage Systems for NPPs' [AERB/SG/D-24 (Rev. 1)]

17) Safety Guide on 'Criticality Safety in Fissile Material Handling Facilities' [AERB/BE-FCF/SG-3]

18) Safety Guide on 'Equipment Qualification for Nuclear Power Plants' [AERB/SG/D-27]

19) Safety Guide on Management of Emergency Arising from Radiation Sources, Equipment and Installation [AERB/RF/SG/NRE-2]

20) Safety Guide on 'Nucleonic Gauges' [AERB/RF/SG/NG (REV.-1)]

21) Safety Guide on 'Gamma Radiation Processing Facilities' [AERB/RF/SG/GRAPF]

22) Safety Guide on 'Gamma/X-ray Irradiation Chambers' [AERB/RF/SG/GIC]

23) Safety Guide on 'Nuclear Medicine' [AERB/RF/SG/NM]

24) Safety Code on 'Design of PHWR based NPPs [AERB/NPP-PHWR/SC/D (REV. 2]

25) Safety Guide on 'Well Logging' [AERB/ RF/SG/WL]

26) Safety Guide on 'Safety Classification and Seismic Categorization for SSCs' [AERB/SG/D-1 (REV. 1)]

27) Safety Guide on 'In Service Inspection of Nuclear Power Plants' [AERB/NPP/SG/O-2 (REV. 1)]

28) Safety Guide on 'Periodic Safety Reviews for NPPs [AERB/NPP/SG/O-12 (REV. 1)]

29) Safety Guide on 'Medical Management of Persons Exposed in Radiation Accidents' [AERB/SG/MED-1(REV.1)]

6.4 SAFETY DOCUMENTS UNDER PUBLICATION IN HINDI

The following published AERB safety documents are in process of translation in Hindi:

1) Safety Guide on "Regulatory Control of Radioactive Discharges to the Environment and Disposal of Solid Waste" [AERB/NRF/SG/RW-10]

6.5 REVIEW OF IAEA DRAFT SAFETY STANDARDS

India has been significantly contributing towards fulfilling mission of IAEA, since its first international conference in Geneva in 1955, Chaired by Dr. Homi Jahangir Bhabha. One such area is development of Safety Standards and Nuclear Security series. AERB contributes towards development of all Safety Standards and Nuclear Security series of IAEA through following means:

6.5.1 Participation in Standards Committee

IAEA has five safety standards committees viz.,

(i) Emergency Preparedness and Response Standards Committee (EPReSC)

(ii) Nuclear Safety Standards Committee (NUSSC)

(iii) Radiation Safety Standards Committee (RASSC)

(iv) Transport Safety Standards Committee (TRANSSC), and

(v) Waste Safety Standards Committee (WASSC).

These Safety Standards committees of IAEA focus on respective areas important to Safety and Security. AERB experts have been contributing in all the above mentioned IAEA Standards Committees.

These standards are further reviewed by the Commission on Safety Standards (CSS) consisting of senior experts from IAEA member states holding national responsibilities for establishing standards in their respective countries. Chairman, AERB is the member from India in the CSS.

6.5.2 Review of Draft IAEA Standards

From India, AERB coordinates and leads the review of the draft standards. In review of the draft standards, views of experts from the licensees and TSOs are also solicited on the draft IAEA standards. The following draft IAEA Safety Standards/Document Preparation Development Profile (DPP) were received/reviewed during the period:

1) Radiation Safety in the Use of Sources in Research and Education (DS470)

2) Arrangements for Preparedness and Response for

a Nuclear or Radiological Emergency (DS504)

3) Assessment of the Safety Approach for Design Extension Conditions and Application of the Practical Elimination Concept in the Design of NPPs (DS508)

4) Use of a Graded Approach in the Application of the Safety Requirements for Research Reactors (DS511)

5) Borehole Disposal Facilities for Radioactive Waste (DS512)

6) Human Induced External Hazards in Site Evaluation for Nuclear Installation (DS520)

7) Development and Application of Level-1 Probabilistic Safety Assessment for NPPs (DS523)

6.5.3 Participation in Development of IAEA Safety Standard/DPP

AERB experts also participate in development of many of the draft IAEA Standards depending on their specific area of expertise in safety regulation and provide comments.

CHAPTER 7

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 scientifically sound regulatory decisions. Safety analysis and research activities are carried out by AERB as a part of its regulatory activities. Several important developmental studies were taken up by AERB and completed during this year. A brief overview of these activities is presented in the following sections.

7.1 REACTOR THERMAL HYDRAULICS SAFETY STUDIES

7.1.1 CFD Analysis of Flow (Turbulence) Induced Vibration of Fuel Bundle

Computational Fluid Dynamics (CFD) and Computational Solid Mechanics (CSM) coupling methodology was developed in ANSYS Workbench for estimating the associated deflection of fuel bundle due to local flow characteristics arising with flow (turbulence) induced vibration inside coolant channel for a typical TAPS-3&4 PHWR fuel bundle. The simulations were performed using ANSYS, where the fluid domain is solved using FLUENT module and the structural domain is solved using the Mechanical Module and data transferring process was performed by System Coupling Module. Simulations of fully developed, single-phase, turbulent flow in a 37-pin bundle, with two cases a) without end plate and b) with end plate were carried out. The total deflection of fuel bundle as well as directional deflection were estimated. The analysis provided insights of deflection of fuel bundle due to flow induced turbulent characteristics.

7.2 SEVERE ACCIDENT STUDIES

7.2.1 CFD Studies to Investigate Effect of Baffles around Calandria Vessel on Heat Transfer Characteristics

CFD studies were taken up to investigate the effect of baffles around the calandria vessel on heat transfer characteristics during severe accident scenarios in the PHWRs. A two-dimensional model containing the calandria vault and calandria vessel was developed and heat flux equivalent to the decay heat of molten fuel was applied at the calandria vessel inner surface. Boussinesq approximation was employed to capture the natural circulation phenomenon. Transient simulations were continued till boiling temperature was attained. The variation of temperature at the bottom of the calandria with varying heat flux is shown in Figure 7.2.1. It was seen that the boiling occurs at the bottom of the calandria for cases above 175 kW/m^2.

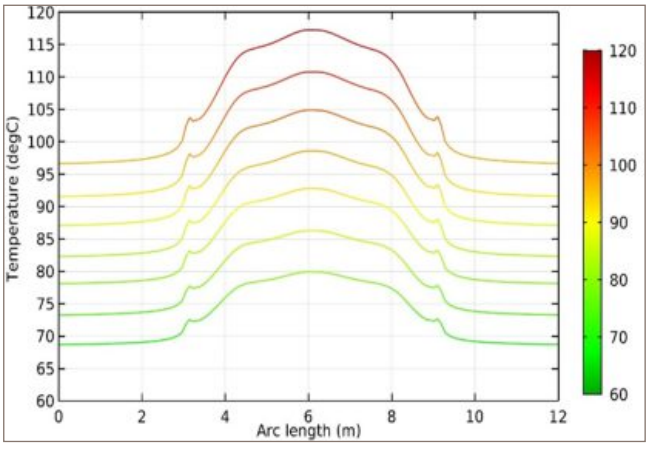


Figure 7.2.1 : Temperature across the Calandria Bottom for different Cases

7.2.2 Numerical Studies on In-vessel Retention of Corium in PHWRs Calandria Vessel

The Core Melt Retention Facility (COMREF) is established in SRI engineering hall to investigate the in-vessel retention capability of calandria vessel of PHWR during postulated severe accident conditions. To investigate the effect of various pipe penetrations that could affect vapour bubble flow and influence departure from nucleate boiling (DNB) phenomena, two types of obstructions were welded to the bottom surface of the test vessel. One of the obstructions is a cut portion of a pipe having same diameter (250 NB) as that of the moderator outlet pipe of calandria. The other obstruction is a smaller pipe having diameter of 100 NB. DNB was observed at the junction between 100 NB pipe and test vessel. However, DNB was not observed at the junction of 250 NB pipe section. Numerical analysis was also carried out to understand the DNB phenomena. The effect of flow obstruction caused by the moderator outlet pipes and effect of vessel thickness and pipe diameter were studied. Formation of hotspots was observed around the pipe obstruction. It was found that the vapour trapped inside the 100 NB pipe was leading to formation of

local hot-spots and concentration of heat flux in the vicinity of junction. It was concluded that the DNB observed during the experiments was due to the presence of high heat flux hotspots at the junction between pipe obstruction and test vessel bottom surface.

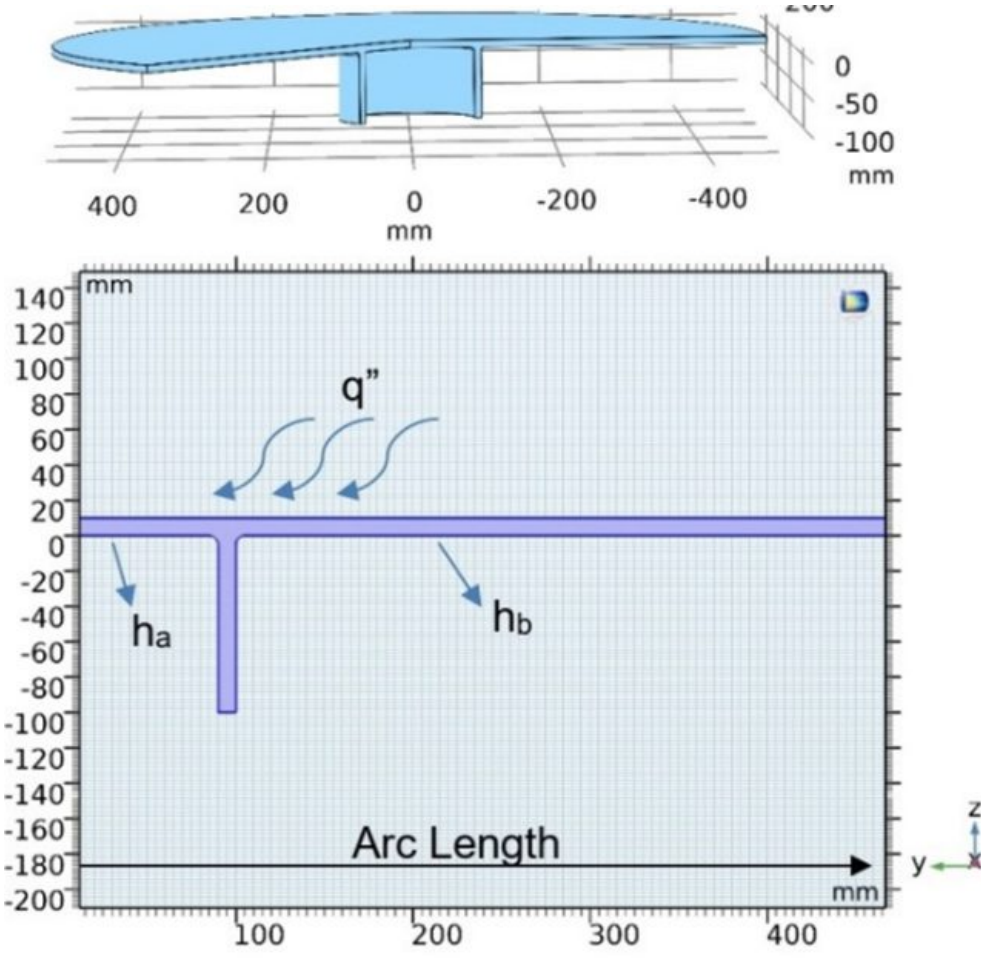


Figure 7.2.2(a) : Computational Domain

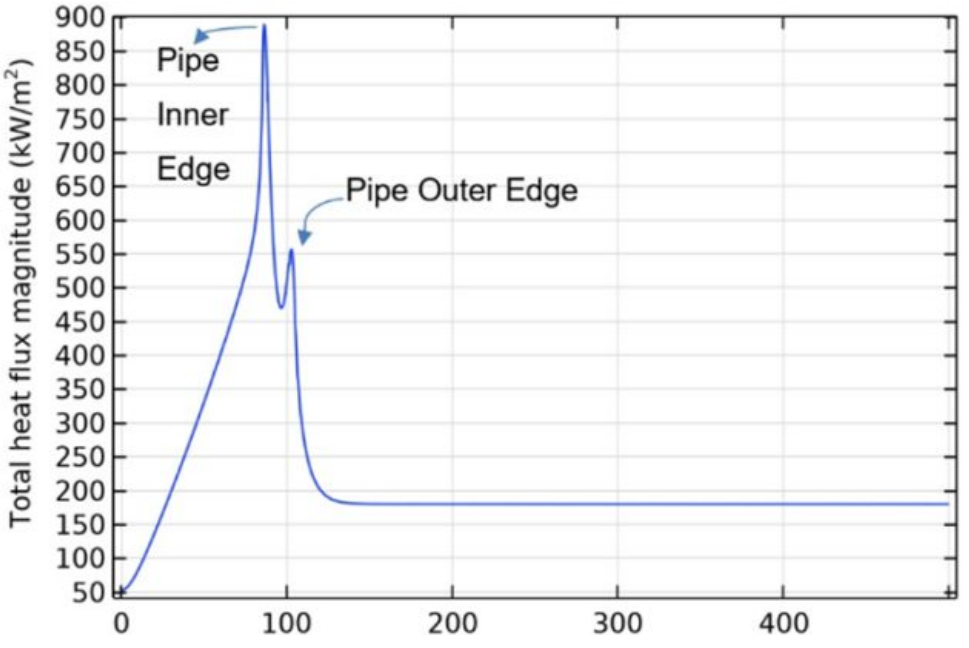


Figure 7.2.2(b) : Heat Flux Variation at the Outer Surface

7.3 SAFETY ANALYSIS CODE DEVELOPMENT & BENCHMARKING

7.3.1 Development of In-house 1-Dimensional, 2-Phase System Thermal Hydraulic Code, NuPAC (PS)

A one-dimensional two-phase (Homogeneous Equilibrium Model) thermal hydraulic computer code, NuPAC (Nuclear Plant Analyzer Code) for transient analysis of water and sodium system was developed using PYTHON 3.6. A semi-implicit finite difference numerical scheme was used for the solution of conservation equations. Various models required for closure of conservation equations were also developed. A two-loop natural circulation system in series with sodium and water as coolant in each loop was simulated using this code 7.3.1(a). Heat flux as boundary on the sodium loop and constant temperature boundary condition on the cooler of water loop was specified. The mass flow rate and rise in temperature across heater in sodium loop for four different heat flux boundary conditions are shown in Figure 7.3.1(b) and 7.3.1(c) respectively. The NuPAC prediction for water loop was compared with RELAP5 with IHX temperature obtained from NuPAC as boundary condition. The mass flow rate variation for one of the cases is as shown in Figure 7.3.1(d). The prediction was found to be in good agreement.

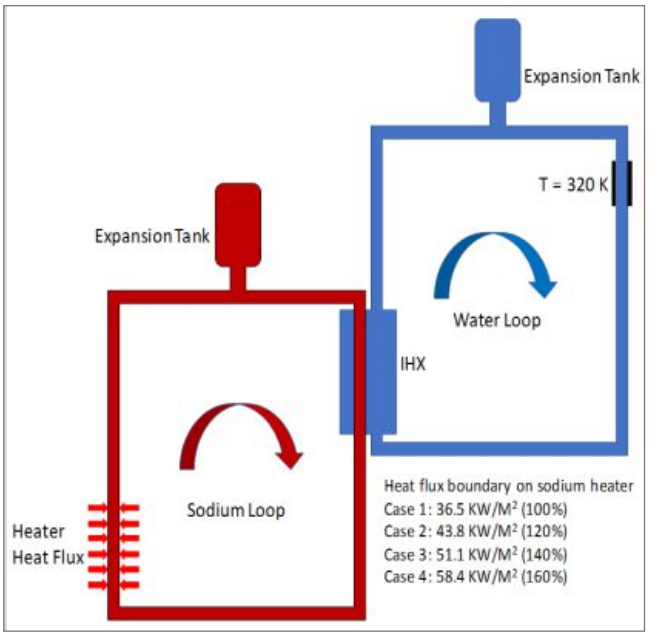


Figure 7.3.1(a) : Two Loop Natural Circulation in Series with Sodium and Water as Coolant

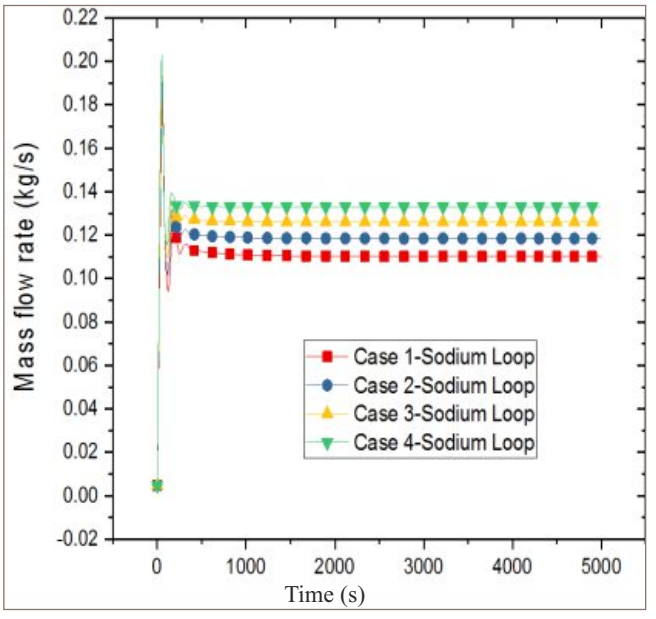


Figure 7.3.1(b): Sodium Loop Mass Flow Rate for 4 Cases

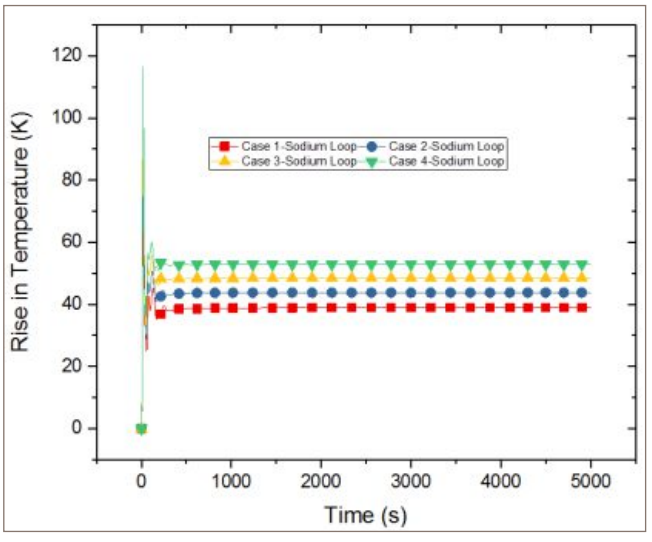


Figure 7.3.1(c) : Sodium ΔT across the Heater

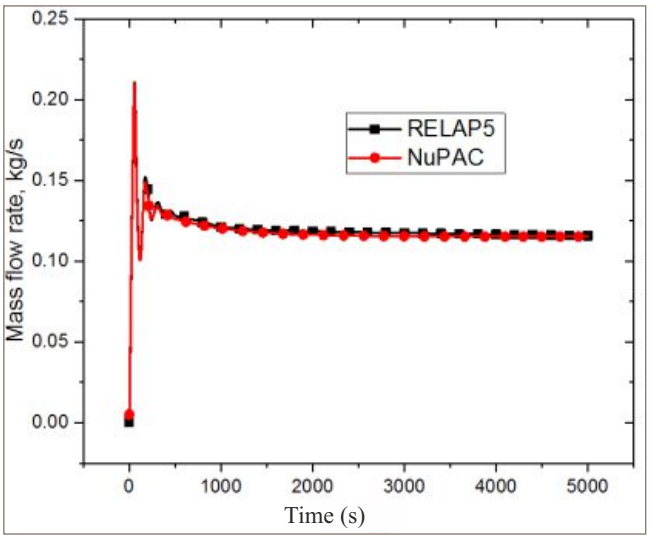


Figure 7.3.1(d): Comparison of Mass Flow Rate NUPAC & RELAP5

7.3.2 Development of PCCS Model for Containment Thermal Hydraulic Analysis

A computer code for simulating passive containment cooling system (PCCS) based on natural circulation concept was developed, upgraded and integrated with in-house containment thermal hydraulic code 'THYCON'. The integrated code is capable of performing coupled calculations of containment thermal-hydraulics and PCCS transients simultaneously. The integrated code was benchmarked for long term containment response during a postulated severe accident. Subsequently, it was applied to investigate effect of conceptual PCCS on containment thermal-hydraulics of a 220 MWe PHWR. Results showed that sustained heat removal by PCCS is possible and it can reduce the containment peak pressure (Figure 7.3.2). Here, FS-IT refers to Finite Sink Insulated Tank and FS-NIT refers to Finite Sink Non-Insulated Tank. Initially some variations in the natural circulation flow were observed, however they do not hamper the heat removal capability.

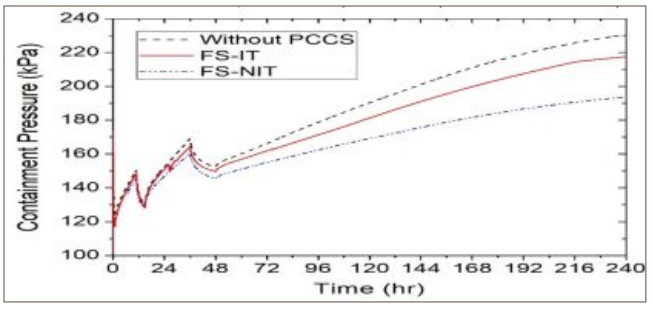


Figure 7.3.2 : Comparison of Containment Pressure with and without PCCS

7.3.3 Development of Containment Spray Model for Prabhavini

The development of an integrated source term estimation code PRABHAVNI is ongoing at BARC. AERB has been contributing in this code development work. As part of this initiative, containment spray system model was developed and integrated with PRABHAVINI. For validating the code, temporal variation of the pressure estimated with the PRABHAVINI was compared with KAPP-3&4 PSAR PART-B report, obtained using multi-volume containment code PACSR, as shown in the Figure7.3.3 (a). Subsequently, parametric studies were carried out to bring out the influence of spray flow rate, droplet size and time of spray actuation on the containment transients and overall efficacy of spray system. The effect of spray flow rate was studied by varying the flow rate from 100 m^3/hr to 350 m^3/hr. Figure7.3.3(b) shows the effect of droplet size on the containment transients for flow rate of 350 m^3/hr.

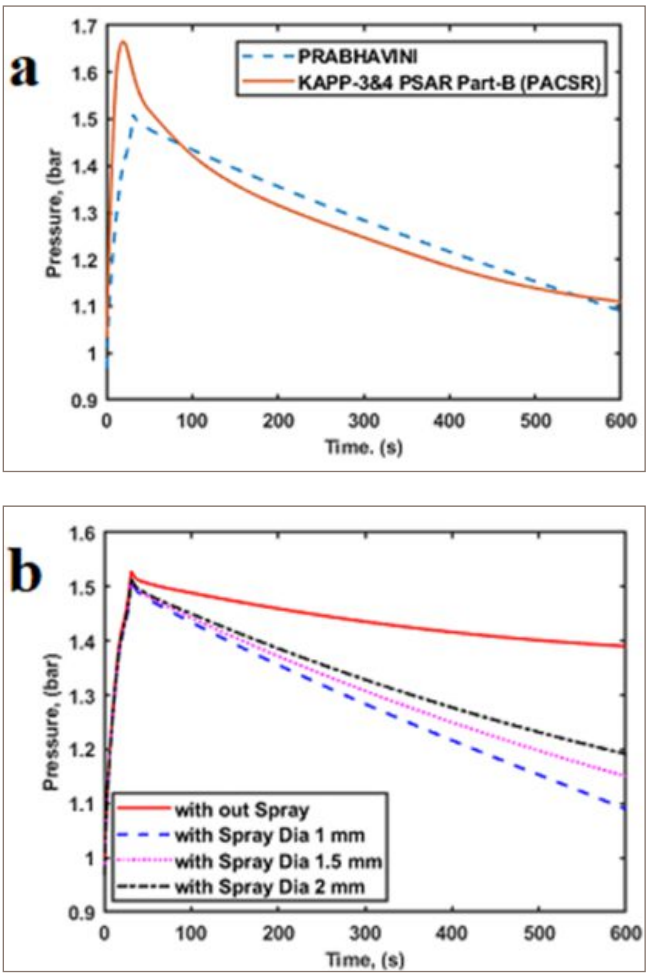


Figure 7. 3.3 (a & b) : The Temporal Variations with respect to various Spray System Operating Parameters

7.3.4 Development of Computational Tools for Fast Reactor Safety Analysis

A computer code was developed to study various transients that occur in a loop type fast reactor. Reactor kinetics with associated feedbacks, primary, secondary and tertiary coolant dynamics and the heat transfer are modelled in the code. As a part of verification and validation of the code postulated events like seismic induced reactivity insertion, spurious pump trip and complete loss of forced coolant circulation leading to buoyancy induced natural circulation were analysed for the Clinch River Breeder Reactor (CRBR).

A computer code has also been developed to simulate pre-disassembly phase during Core Disruptive Accident (CDA) in a fast reactor till boiling of sodium coolant occurs. The code uses point kinetics model for neutronics and lumped model for thermal hydraulics analysis. Reactivity feedbacks are considered in terms of Doppler, fuel axial expansion, radial expansion, steel expansion and coolant expansion.

To further enhance the scope of fast reactor safety analysis, an analytical tool was developed for assessment of stability of the reactor core under normal and off-normal conditions by linear and non-linear methods. The stability regime was characterised by Nyquist criteria, root locus and Lyapunov exponent methods. The tool was used to evaluate stability boundary and stability map for PFBR.

7.4 RADIOLOGICAL ASSESSMENT AND ENVIRONMENTAL SAFETY STUDIES

7.4.1 Development of Version V3.2 of AERB Source Term Estimation Tool (ASTET):

A new feature was added to the AERB Source Term Estimation Tool (ASTET). This feature allows the user to monitor the potential source term present in the containment at any moment just with a click of a button for a selected radionuclide. This feature is in addition to the monitoring of actual release of source term happening through leaks. For this the FORTRAN source code calculating the source term as well as the MATLAB code controlling the GUI were updated. The GUI of ASTET V3.2 is shown in Figure 7.4.1. Apart from this, "Emergency Drill" scenario was made available for KKNPP and PFBR in the dropdown menu. In addition, input decks have been included for cases considered in emergency exercises at KKNPP, NAPS and TAPS (unit#1&2).

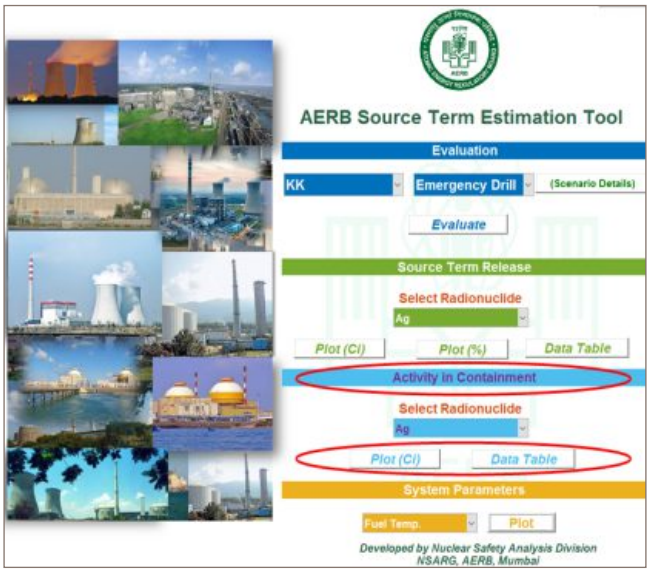


Figure 7.4.1 : GUI of ASTET V3.2

7.4.2 Impact of Land Surface Processes on the Simulation of Sea Breeze Circulation and Tritium Dispersion over the Complex Terrain Site of Kaiga

KGS nuclear power plant site at Kaiga is a complex terrain site with dense forest cover often influenced by land-sea breeze flows during warm summer season. Tritium plume dispersion from Kaiga Nuclear Power Plant (NPP) site was investigated under the influence of land-sea breeze circulations using FLEXPART-WRF models. Sensitivity experiments were conducted with two land surface models of Weather Research and Forecasting (WRF) i.e., Noah and Noah-MP, to study their impact on the wind flow and meteorological characteristics. Mini Boundary Layer Masts and Doppler SODAR observations were used for evaluating the model performance. WRF simulations showed high sensitivity to simulated sea breeze characteristics for the land surface physics model.

It was found that the Noah-MP better predicted the onset time, inland extent, intensity and duration of the sea breeze circulation with lesser statistical error compared to Noah. The improvements in prediction with Noah-MP as compared to Noah were due to the detailed representation of vegetation and soil hydrological processes over the dense forest region, realistic simulation of surface energy and momentum fluxes and reduction in the land-sea temperature contrast by inclusion of separate canopy physics

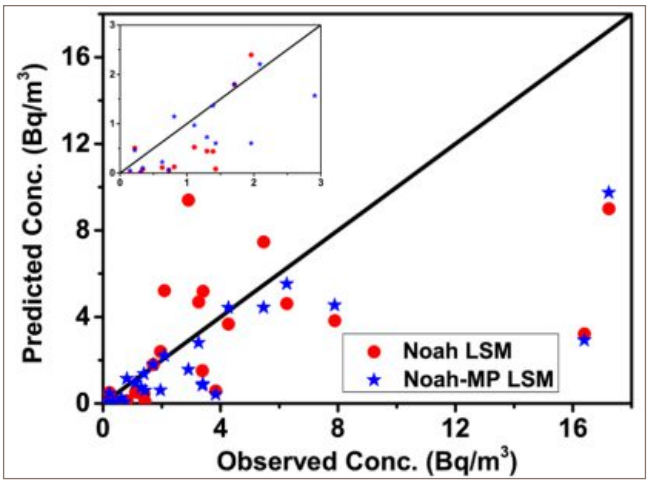


Figure 7.4.2 : Q-Q Plots of Observed Ground Concentrations and corresponding values given by WRF Model with NOAH and NOAH-MP LSM

(Figure 7.4.2). Tritium releases from the Kaiga showed large diurnal variability in the dispersion pattern and air concentrations around the valley. Tritium plume was found to get transported to northwest sector during early morning and morning time by the land-breezes and to the east-southeast sector by the sea breeze during daytime. Predicted tritium activity concentrations at different measurement locations using WRF-Noah-MP meteorological data are in better agreement with measurements.

7.4.3 RS-GIS based Assessment on Effect of Seawater Intake Structure on the Coastal Morphology at KKNPP

A state-of-the-art sea water intake structure has been constructed for KKNPP (Figure 7.4.3). To assess the environmental impact due to this structure, high resolution satellite data for the pre and post construction period was analysed. The High-Water Line (HWL) digitized from the time series satellite data was compared and image analysis was performed to identify the changes in the morphology of the coast. The initial observation shows that there is no significant change in the high-water line. Only minor changes are observed in the sedimentation pattern at both sides of the wall. Studies reveal that due to this structure, so far, no major impact is observed in the nearby environment.

Figure 7.4.3 : Sea Water Intake Structure of KKNPP (Source: Google Earth Pro)

7.4.4 Generation of Site Specific Geo-spatial Baseline Data for GHAVP Site

A study was carried out to generate site specific Geo-spatial baseline data for Gorakhpur Haryana Anu Vidyut Pariyojana (GHAVP) site using remote sensing and GIS technology. The study area includes 30 km radial zone around the site. The baseline data on geology, geomorphology, land use/land cover, village boundary map with population information, surface water body, road network etc. was generated for the Gorakhpur site (Figure 7.4.4). The village map and road network data would be useful for monitoring of emergency planning, evaluation of evacuation routes during off-site emergency. Similarly, the land use/land cover data would be used as background information to compare the geo-spatial changes in the emergency planning zone around the NPP site.

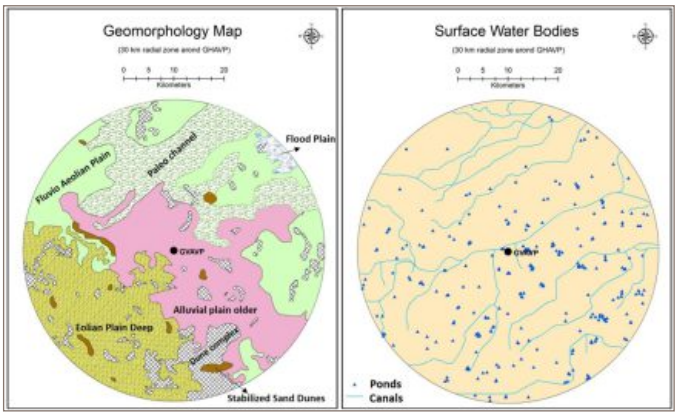


Figure 7.4.4 : Geomorphology and Surface Water Bodies around GHAVP site

7.5 EXPERIMENTAL STUDIES

7.5.1 Water and Steam Interaction Facility (WASIF)

Task on setting up Water and Steam Interaction Facility (WASIF) Phase-II focusing on suppression pool hydrodynamics and efficacy of containment sprays has been taken up in collaboration with BARC. A test vessel of 2.5 m diameter and 5 m height has been installed within the high bay of the SRI engineering hall and the insulation work has been completed. Subsequently the fabrication and erection of steam, water and pneumatic piping and associated components are in progress.

7.5.2 AGMS and Coolant Channel Heat-up Facility

An experimental facility is set-up at SRI-AERB for investigating coolant channel heat-up and annulus gas monitoring system related safety issues. There are nine PT-CT assemblies and each one is provided with tubular heater of 3.6 kW. The heating rate varies linearly from one end to the other so as that the PT inner surface temperature varies from around 250°C to 300°C. The direction of heating is reversed in

alternate channels. Experiments were conducted using CO_2 as the working fluid at different flow rates and heat transfer conditions in order to estimate their influence on the flow characteristics within the annulus gas system. Eight out of nine channels in the facility were isolated and the tests were conducted in the 6^{th} channel (1,2). Thermocouples were placed at five different locations along the channel length in the annulus gap at different angles (90° and 270°) and depth. Temperature measurements were taken at different locations on inner and outer surface of PT. Experiments were continued till the system attained steady state. The experimental results and associated data will be compared with the earlier results obtained using air as the working fluid in order to understand the influence of working fluid on the heat transfer characteristics.

7.5.3 Experimental and Theoretical Studies to Investigate the Behaviour of Iodine in Reactor Containment

An accurate estimation of iodine source term is challenging as iodine behaviour is governed by many factors such as thermal-hydraulics, aerosol physics, interaction with sump water and atmosphere, deposition onto surfaces, reactions with paint, impact of pH, steam, temperature, radiation etc. For addressing the issues pertaining to the chemical forms of iodine in the reactor containment, its migration behaviour needs to be investigated for obtaining realistic estimation of the source term as well as for designing appropriate techniques for prevention and mitigation of radioactive releases. An experimental set-up was designed and commissioned at SRI Chemistry Laboratory for iodine related experimental studies.

The facility is designed to study the gaseous and aqueous phases of iodine independently and also combination of the both phases. It consists of a containment structure, a sump, spray system, provision for measurement of various parameters, heating arrangement, provision of steam injection and placement of painted surfaces etc. (Figure 7.5.3). Experimental studies were carried out both in the aqueous as well as gaseous phases for studying different safety related parameters pertaining to Iodine. A comprehensive database would be generated based on the studies which is useful inputs for the severe accident analysis codes besides providing more insights on the iodine behaviour inside the containment.

Further, a theoretical study using Fact Sage software is being carried out to understand the possible iodine species formed during the interaction with painted coupons, water radiolysis species, and impurities (mainly organic) present in the sump water under different experimental conditions. In the theoretical studies, the kinetics behaviour of iodine interaction with impurities present in a carrier gas as well as in sump water under different conditions such as concentration of species, temperature etc., is being carried out. The results obtained from the theoretical studies would be validated with experimental activities on the topic.

Figure 7.5.3 : Iodine Experimental Facility

7.5.4 Generation of Electrochemical Parameters as Indicators for Ageing Management of Reactor Component Materials

For the ageing assessment and material degradation of reactor components under different experimental conditions, suitable electrochemical data were generated for carbon steel under various corrosive media. The experimental polarization data generated for fresh and carbon steel immersed in NaCl solution was used to estimate the corrosion rate and other experimental parameters for deducing the remaining life of materials. The generated experimental database was used to model the corrosion process of carbon steel. The study successfully demonstrated the feasibility of electrochemical techniques to investigate the material's corrosion phenomenon under different experimental conditions. The experimental results were compared with theoretical studies under identical experimental conditions which has shown good agreement.

7.6 REACTOR PHYSICS STUDIES

7.6.1 Core Physics Characteristics of Advanced LWRs

Neutron physics characterization of advanced LWRs was carried out using international reactor physics code system DRAGON-DONJON. The core physics parameters of interest, viz., critical boron concentration, core average burnup and radial power profiles as a function of Effective Full Power Days (EFPD), and various reactivity coefficients and the worth of Rod Cluster Control Assembly (RCCA) banks for a clean core condition at Beginning of Cycle (BOC) were simulated and compared with the design calculations. Comparison in general shows good agreement with the reported design values. Comparison has also been made with core physics parameters of KK VVER-1000 reactors. The reactivity worth of RCCA system as a function of their percentage position IN are presented in Figure 7.6.1. It is observed from figure that despite lesser number of RCCAs, the worth in AP-1000 reactor is observed to be more as compared to other two types of PWR. This may be attributed to Integral Fuel Burnable Absorbers (IFBAs) which do not shield the RCCAs and the choice of absorbing material Ag-In-Cd in AP1000. With higher active core height and tighter fuel pin pitch in AP-1000, the epithermal neutron flux can be more and hence, more worth with Ag-In-Cd.

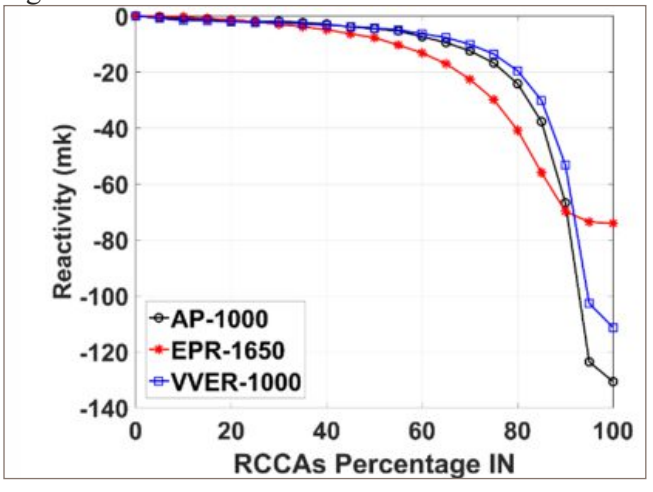


Figure 7.6.1 : Comparison of Worth of RCCAs of PWR type Advanced LWRs

7.6.2 Lattice Physics Analysis of BWR Next Generation UO_2 and MOX Fuel Assemblies

Towards development and validation of in-house physics analysis capability to support safety review, the lattice burn-up calculations were carried out for LEU and MOX fuel assembly (FA) types of BWR using DRAGON code. Specification of modern BWR FAs and reactor state descriptions as given in "Benchmark problem suite for reactor physics study of LWR next generation fuels" was considered for the analysis. Lattice physics results such as infinite neutron multiplication factors, Doppler, void and temperature reactivity effects, and fission rate distributions were evaluated as a function of burn-up up to 70 GWd/t which was set as the target discharge burn-up of the next-generation fuel considering the increasing trend in discharge burn-up of LWR fuels. Evaluated physics parameters were compared with the results of the international state of the art codes available in the benchmark report which shows good agreement for all parameters. The lattice level void reactivity loads of modern BWR UOX and MOX FAs are given in Figure 7.6.2 as a function of burn-up for various void fractions.

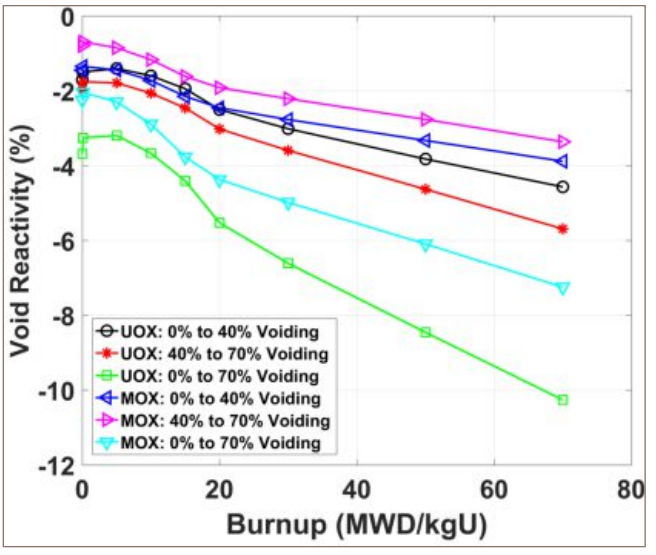


Figure 7.6.2 : Lattice Level Void Reactivity Loads of UOX and MOX FAs

7.6.3 CFD Simulations of Coolant Flow through the Fuel Assembly and Reactor Pressure Vessel

Computational Fluid Dynamics is being increasingly used to solve various design/ optimization problems in nuclear reactor core. It is also being used to analyse different incidents/ events associated with changes in the core thermal hydraulic state and associated reactivity changes. International benchmarks are being organized to assess and validate the tools and methods being used to perform such exercises. AEARB is participating in such an exercise organized by Working Group-G of Atomic Energy Research (AER) forum for VVER safety research. The first of

these exercises is to simulate the coolant flow through a typical fuel assembly of a VVER-440 reactor. Specifically, the simulations are being performed to assess the possibility of enhancement in coolant mixing due to introduction of a 'mixing vane' on the grid spacer of the existing fuel assembly design. The second exercise being conducted on the same platform involves simulation of coolant flow through the pressure vessel of a typical VVER-440. Specifically, the simulations are being performed to assess the asymmetry introduced due to injection of low temperature coolant through one of the six cold legs (5ºC lower than the other 5 cold legs). The temperature asymmetry due to this at core inlet is shown in Figure(blue & red colours indicate the lowest and highest temperatures respectively). Both the exercises involve inter-code comparison as a means of assessment of results. Further, the second exercise also involves comparison with the measured/experimental data for validation. Both the problems are being solved at AERB as steady state simulations. The exercise involves creation of a geometrical model and generation of a computational mesh. Further, different turbulence models and discretization schemes are being tested for their performance.

7.6.4 Safety Analysis of a Molten Salt Breeder Reactor

A computational tool was developed to characterize the dynamic aspects of a Molten Salt Breeder Reactor (MSBR). The tool uses delayed point kinetics equation where delayed differential equations (DDE) are solved for neutronics analysis during the transient. Several lumps of fuel salt and graphite are used for thermal hydraulic calculations. Reactivity feedback is taken in terms of temperature coefficient for fuel and graphite. A typical conceptual design of 2250 MWt MSBR has been studied using the tool. Several enveloping cases e.g. step and ramp reactivity insertion at zero power critical condition and full power equilibrium condition were analysed. The results are compared with other international evaluations and found to be consistent.

7.7 STRUCTURAL ANALYSIS AND MATERIAL STUDIES

7.7.1 Effect of Clearance, Grooves and Ironing out on Residual Stress in PT Rolled Joint

Pressure Tube (PT) rolled joint is an important joint in the PHWR. This joint connects the Zr-2.5%Nb PT to martensitic stainless-steel End Fitting (EF) to complete the coolant flow path. Rolled joint formation using the rolling tool imparts elasto-plastic deformation leading to multi-dimensional state of residual stress in the tube. This state of stress is important from the consideration of leak tight joint and lower tensile residual stress. The developed residual stress in the tube is significantly influenced by material constitutive behaviour. The cyclic behaviour of material, which was taken into consideration by Chaboche nonlinear kinematic hardening model, had the most predominant influence on the development of residual stress. Even

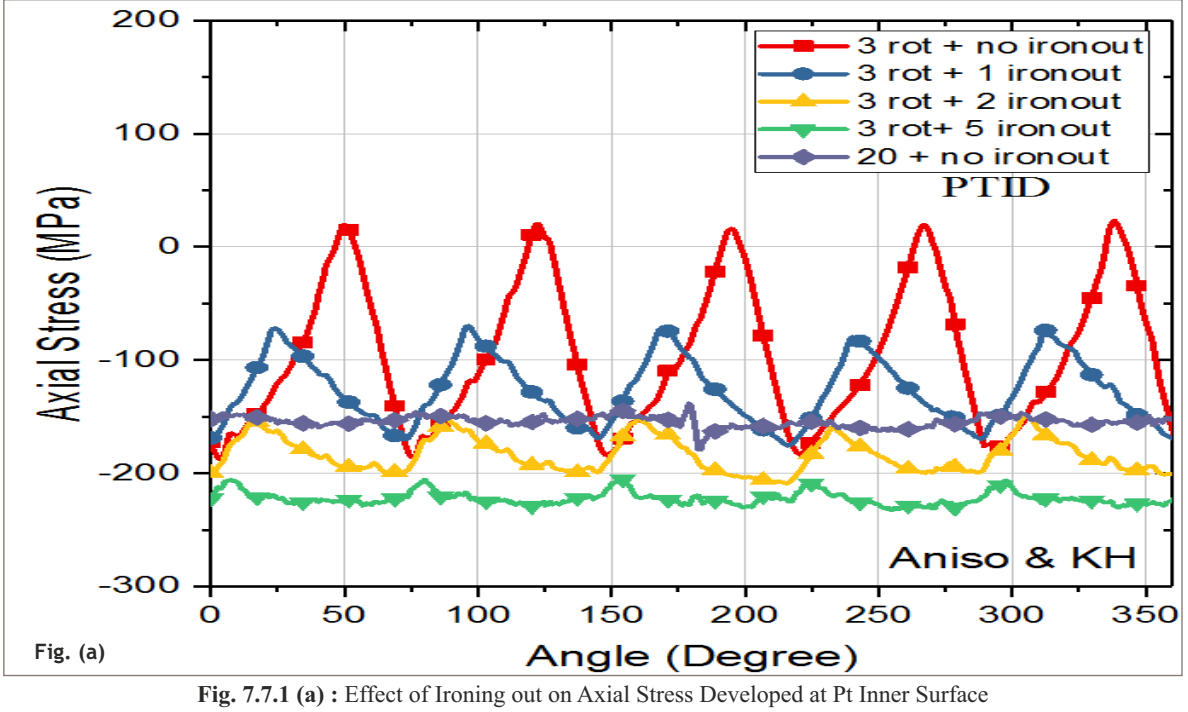
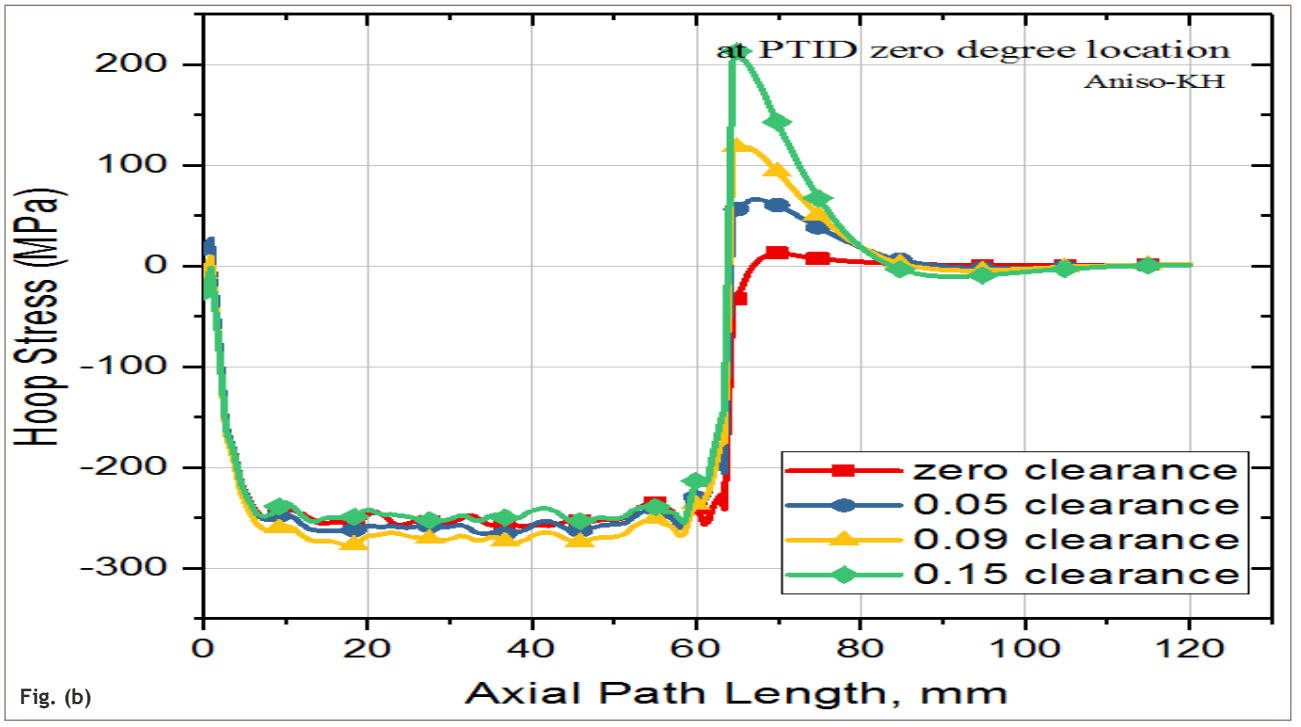


Fig. 7.7.1 (a) : Effect of Ironing out on Axial Stress Developed at Pt Inner Surface



7.7.1 (b) Residual Hoop Stress along the Axial Path for various Radial Clearance Values

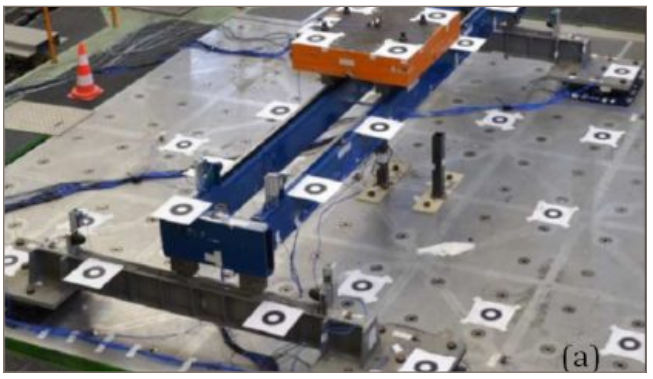
anisotropic yielding of the pressure tube, although to a lesser extent, also affects the residual stress and the contact pressure.

Investigations were carried out using the three-dimensional model on the factors, such as the ironing out step in rolling, clearance and the presence of the grooves, which can affect the residual stress developed in the joint. Analysis showed that ironing out step during roll expansion smoothens the stress gradients along the circumference and reduce the peak tensile stresses (Figure 7.7.1[a]). Further investigations showed that clearance is an important parameter which should be tightly controlled during the roll expansion. High clearance not only results in high tensile residual stress (Figure 7.7.1[b]) in the transition region but it also results in higher hydrostatic stress gradients. And this hydrostatic stress gradient is very important from the hydrogen diffusion perspective. Studies on grooves revealed that residual stress developed in the rolled region showed axial stress gradients under the influence of grooves. However, the residual stress in the transition region is unaffected by the presence of grooves.

7.7.2 Dynamic Analysis of Overhead Crane of NPP

An overhead crane used in an NPP is a typical equipment having low rigidity and large response amplification under dynamic loadings. A strong earthquake might cause nonlinear behaviour such as a slip or leap, which may result in derailing from the track or fall from height. Therefore, an analytical work is initiated as part of international Seismic simulation of Overhead Crane (SOCRAT) Benchmark organised by OECD-NEA (Nuclear Energy Agency), IRSN and EDF. The objective of the SOCRAT international benchmark is (i) to identify best modelling practices of crane bridge devices and (ii) to identify relevant failure criteria. The mock-up is a simplified 1/5 scaled model of a 22.5 m long overhead crane bridge. The mock-up of the crane bridge is made up of several components as shown in Figure 7.7.2 (a).

FE code ABAQUS is used for modelling and analysis of the overhead crane bridge and its components using shell, solid and beam element. Most of the components model are based on their geometric and material properties, however load cell supporting the crane is modelled through formulation of User Element (UEL). Modal analysis of crane and its components are carried out using free-free and fixed condition. Subsequently dynamic analyses of crane were carried out. Simulation (Figure 7.7.2 [b]) and experimental results are in good agreement. The dynamic analysis accounting friction between trolley wheels and rails is in progress.



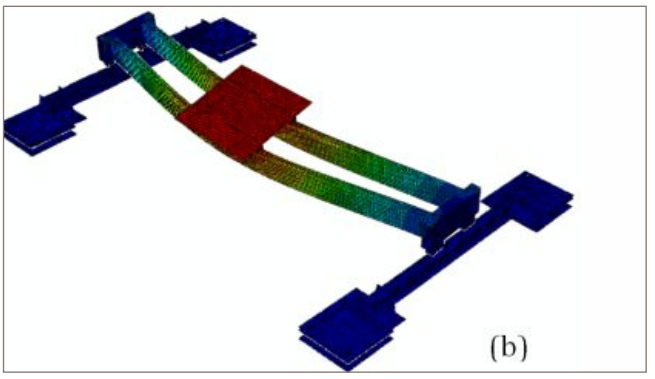
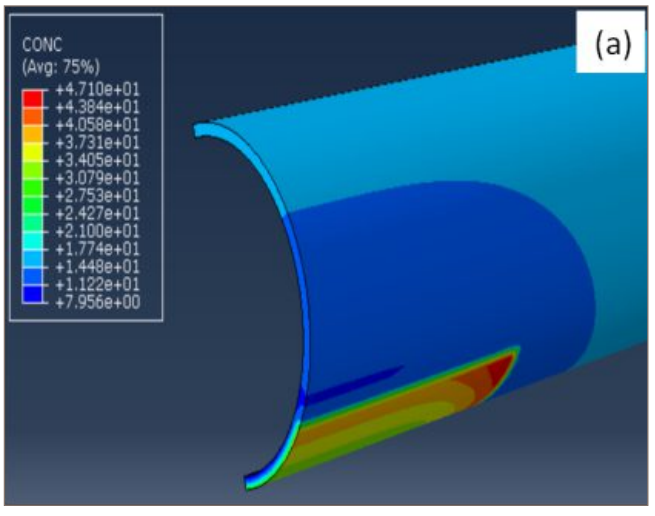


Figure 7.7.2(a) : Scaled Overhead Crane Bridge and
Figure 7.7.2 (b) : Deflected Shape of Overhead Crane Bridge during Dynamic Excitation

7.7.3 Modelling of Hydrogen Diffusion in MAPS-1 PT in Contact with Water

Root cause analysis of MAPS-1 pressure tubes (PT) (O-9 & Q-9) leak has concluded that localized corrosion and thermal gradient due to boiling of water at PT outer surface caused delayed hydride cracking(DHC)initiation and growth. Migration of hydrogen towards PT outer surface due to temperature gradient was modelled in this exercise using ABAQUS. Benchmark exercises were performed for modelling of hydrogen diffusion due to thermal gradient and results were compared well with the experimental findings.

3D model of MAPS-1 PT was developed and analyzed for simulating hydrogen diffusion towards pressure tube outer surface due to leaked end shield water. Steady state and transient thermal and mass diffusion analysis was carried out for a constant leaked water level at PT outer surface with validated numerical model considering hydrogen in single phase (solid solution) as shown in Figure 7.7.3.



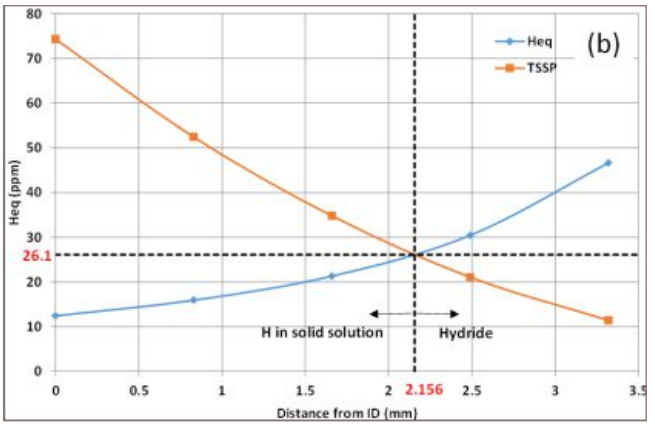


Fig.7.7.3: In Partial Wetted Pressure Tube (a) Steady State Spatial Distribution of Heq & (b) Variation of Solubility of Hydrogen and its Precipitation With thickness

Since single phase simulation results indicates the possibility of hydride formation near PT outer surface (Figure 7.7.3 [b]). Exploration of numerical modelling technique for two phase (solid solution and hydride) hydrogen diffusion is under progress.

7.8 FIRE SAFETY STUDIES

7.8.1 Fire Rating of Fire-Resistant Panels

Fire barrier materials off different types are extensively used in NPPs to mitigate the consequences of a fire by protecting the safety systems and other items important to safety. MAPS has designed composite type panels/doors to compartmentalize battery banks, switch gear and inverters provided for ensuing Class-II power supply for ensuring fire safety. To assess the fire performance of these panels, a joint experimental work was taken up. A small enclosure as shown in Figure 7.8.1(a) was designed, constructed and installed at SRI, with support from MAPS. Specimens provided by MAPS with mineral wool and ceramic wool packing were

tested by subjecting them to standard fire conditions as per IS 3614: Part 2. The capability of the samples to satisfy the specified integrity and insulation criteria for fire exposure is checked and estimated fire resistance rating was reported. Temperature profiles of one of the tests is shown in Figure 7.8.1(b). The experimental results were satisfactory.

The experimental results were used to validate a 2D heat transfer analysis carried out using COMSOL for estimating fire rating of the panels. Heat conduction through the solid materials of panel, convection and radiation on the inner and outer surfaces were modelled. For mixed convection conditions prevailing within the furnace, heat transfer coefficient of 14-15 W/m^2-K was used. A comparison of simulated and experimental temperature is shown in Figure 7.8.1(c).

Figure 7.8.1 (a): Reduced Scale Facility for Testing FR Panels

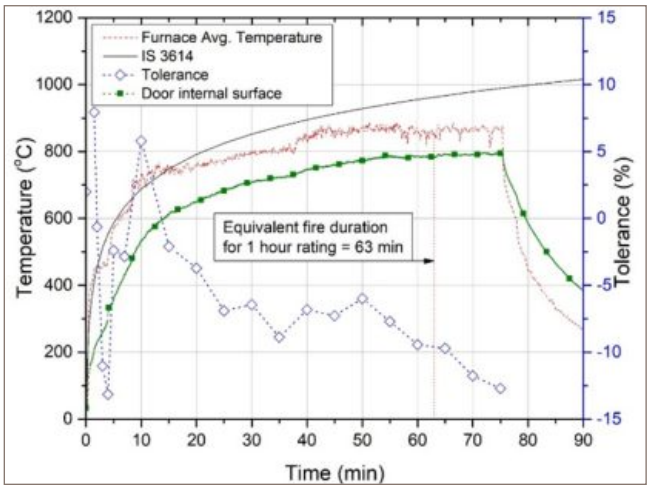


Figure7.8.1(b): Temperature Profiles during a Test Used for Determining FRR

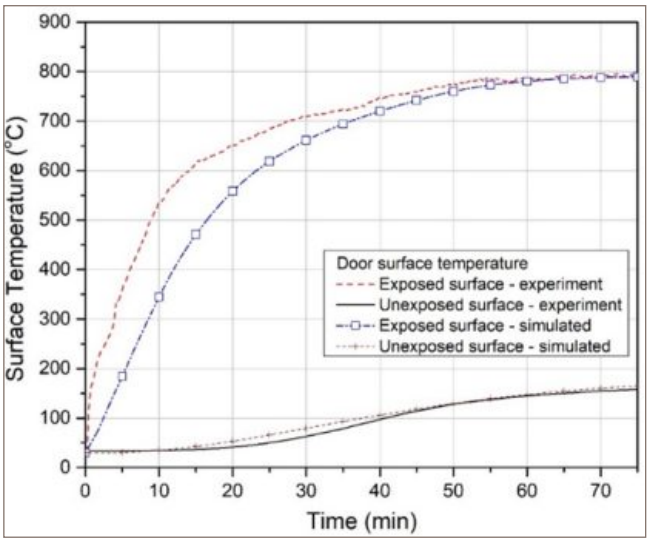


Figure 7.8.1 (c) : Experimental and Simulated Surface Temperature

7.8.2 Thermal Behavior of Transportation Casks under Postulated Fire Conditions

Transportation casks are commonly used for transporting radioactive waste materials from nuclear power plants to fuel reprocessing plants or disposal sites. In the annular region sandwiched between the innermost and outermost stainless steel walls of the cask, a thick layer of lead is contained as a shielding material in order to minimize the radiation dose to the public domain. The ability of such casks to withstand thermal (fire) tests is assessed by numerical simulation. As part of in-house capability development for such assessment, CFD simulations are initiated to model and study the behaviour of lead casks under accidental fire scenario where it was exposed to an average ambient temperature of 800°C, for about 30 minutes. The melting of lead is modelled based on enthalpy-porosity formulation. In this method, the liquid-solid mushy zone was treated as a porous zone with porosity equal to the liquid fraction in which the porosity decreases from 1 to 0 as the material solidifies. The melting of the lead starts around 10 minutes at the corners of the cask and as the time progresses, the total amount of lead melted also increases. The percentage of lead melted at the end of 10 min was only 2.3%; half way through the test, it was 23.74% and by the end of 30 min fire test, the lead melted was 94.5%.

7.9 SAFETY STUDIES TO SUPPORT REVIEW AND ASSESSMENT

7.9.1 Seismic Soil Structure Interaction Analysis of Station Auxiliary Building of Gorakhpur Haryana Anu Vidyut Pariyojana (GHAVP)

Gorakhpur Haryana Anu Vidyut Pariyojana (GHAVP) is situated in an alluvial deposit of~400 m. In order to study impact of alluvial deposit and ground improvement on raft foundations, AERB carried out seismic soil structure interaction analysis of Station Auxiliary Building in specialized software SASSI. The analysis studied behaviour of structure under seismic excitation including various load paths and vibration of structural features at various elevations under design basis ground motion. Few sample results obtained as part of the study are shown in Figure 7.9.1. The outcome of the study was used to compare the findings of similar analysis submitted by NPCIL for design safety review.

7.9.2 Numerical Simulation of pile behaviour at Gorakhpur Haryana Anu Vidyut Pariyojana (GHAVP) Site with respect to Test Data

For structures founded on combined pile raft foundation (CPRF), appropriate simulation of pile behaviour is critical for safety of foundation design. Calibration and validation of the numerical model is an important step in this exercise considering the large amount of uncertainties that exist in estimating soil behaviour and settlement of the foundation.

A study was undertaken to calibrate the numerical model using the results of vertical pile load test at GHAVP site. The objective was to arrive at the most appropriate numerical parameters to simulate the pile behaviour observed during the test. The numerical model was developed in Abaqus software and iteratively calibrated using the results of initial pile test. All the pile resistance parameters (viz. skin friction, end bearing, and resistance in ground improved (GI) layer) and its progression with pile settlement as observed in pile tests could be reproduced in the numerical simulation. The information available from this study provided critical inputs towards safety review of soil structure interaction aspects of GHAVP-1&2.

The 3D model of the test pile, anchor pile surrounding test pile and the soil media around is shown in Figure 7.9.2.1. Comparison of load settlement curve, GI resistance, skin friction, and end bearing between test results and calibrated model is shown in Figure-7.9.2.2 (a) to (d).

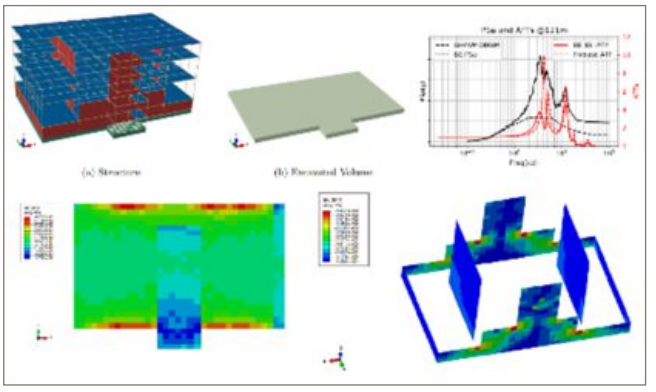


Figure 7.9.1 : Figures showing Structure, Excavated Volume, Resultant Forces in Raft and Wall and Floor Response in terms of Response Spectra

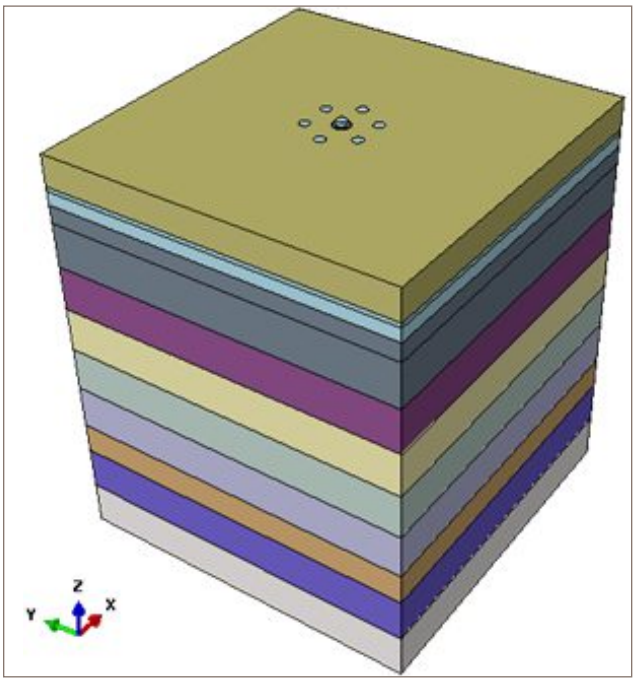


Figure 7.9.2.1 : 3D Model of the Test Pile, Anchor Pile Surrounding Test Pile and the Soil Media around the Piles

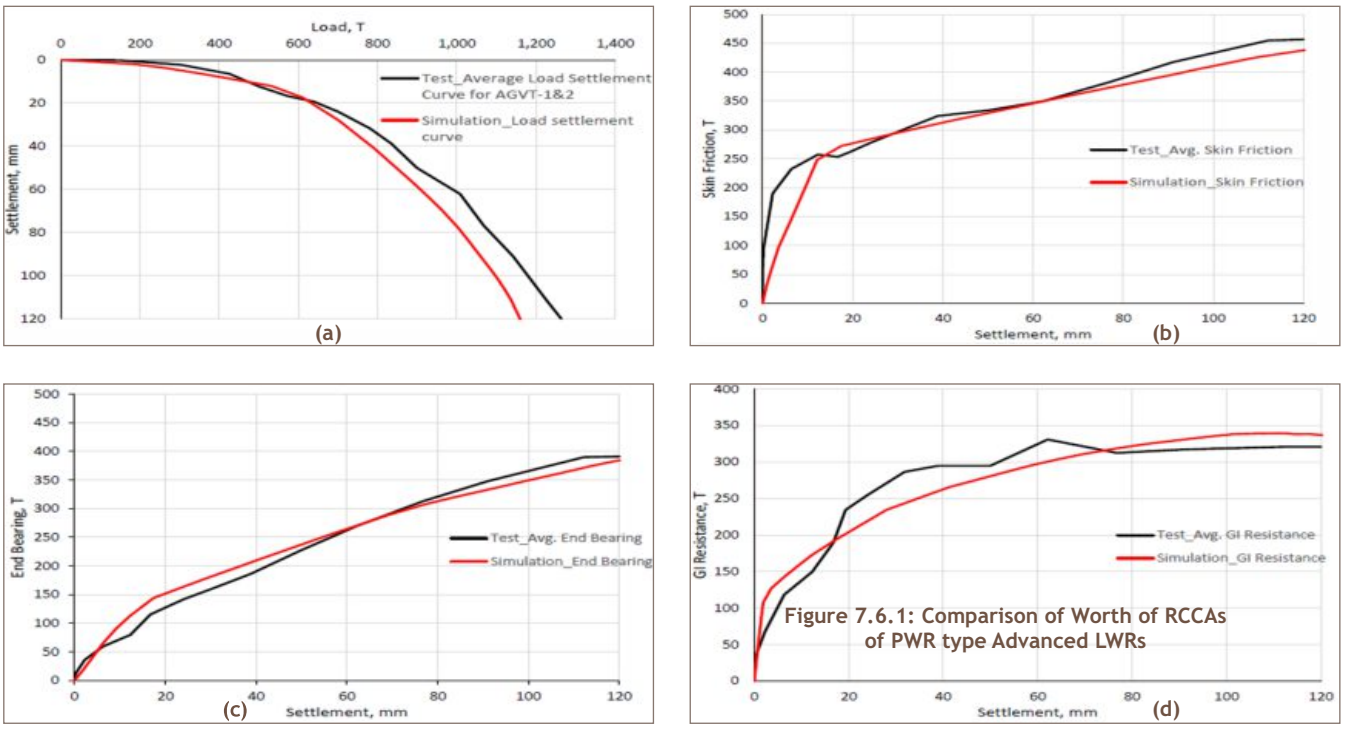


Figure 7.6.1: Comparison of Worth of RCCAs of PWR type Advanced LWRs

Figure 7.9.2.2 : Comparison of (a) Load-settlement, (b) Skin Friction, (c) End Bearing, (d) GI Resistance, between Pile Test Results (black) and Simulation (red).

7.9.3 Benchmarking of Seismic SSI Analysis for Embedded Structures

Several structures of nuclear power plants have different depths of embedment. In addition, advanced reactor technologies like Small modular reactors (SMRs) have deeplyembedded foundations whichrequires additional technical considerations with regard to soil structure interaction. Towards generating better understanding on soil structure interaction behaviour of embedded structures, benchmark SSI analysis of a reactor configuration identified in NUREG-6896 was undertaken, Figure - 7.9.3.

The reactor configuration considered for the study comprised of a cylindrical containment structure embedded to different depths. SSI models were developed in SASSI for different embedment depths and analyses were carried out for different properties (uniform soft soil, uniform hard soil, layered soil) and three angle of incidence for SV waves. The frequency responses from the analysis were compared with the results published in NUREG.

It was observed that for uniform soft soil and uniform hard soil columns, the response spectra are not affected by the angle of incidence irrespective of embedment depth. Additionally, the free field spectra are quite different from the kinematic interaction spectra for embedded structures which confirmed the need for kinematic interaction effects in embedded structures.

Good comparison in predicted frequencies was observed between the responses from this analysis with those published in NUREG-6896.

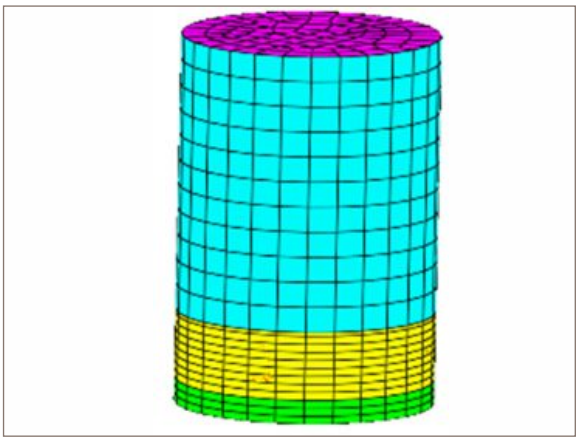


Figure 7.9.3 : Finite Element Model of the Sample Configuration

7.9.4 Recovery of Uranium from Alkaline Leach Liquor using Novel Adsorbents

For the recovery of uranium from alkaline leached liquor used in uranium mines, containing high monovalent and divalent ions, three different adsorbents/ligands viz. organic, inorganic and

composite have been synthesized, and systematically characterized. The ligands are applied for uranium extraction from synthetic as well as real life uranium leached liquor collected from Tummalapalle mines. This work has been carried out in collaboration with IIT-Kharagpur as part of AERB Safety Research Programmes under Grant-in-Aid Scheme. Organic polymeric ligand is a hyper-branched co-polymer of acrylamide and bis-acrylamide.All the three ligands adsorb uranium selectively at pH ~8.5 and desorb the same at pH ~11.5 in the form of pure precipitate (sodium di-uranate, $Na_2U_2O_7$). The effect of initial pH, adsorbent dose, concentration of uranium, temperature, co-ions etc., on the selective adsorption of uranyl ion were investigated [Figure 7.9.4(a) &7.9.4 (b)]

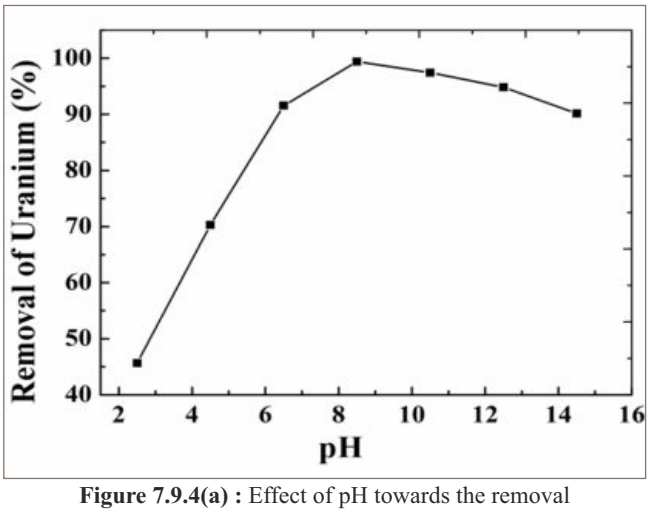


Figure 7.9.4(a) : Effect of pH towards the removal of Uranium using Polymeric Ligand

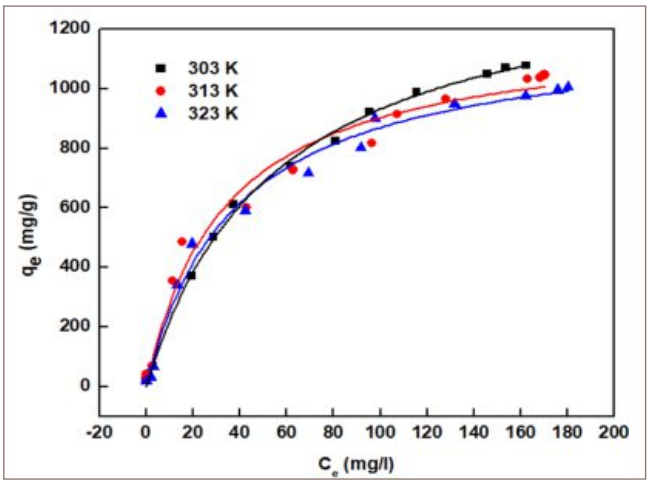


Figure 7.9.4(b) : Isotherm Study of Composite Ligand towards removal of Uranium

From the study, it has been inferred that all the three developed ligands/adsorbents can adsorb uranium from the synthetic uranium solution. Recovery of uranium from carbonate ore leach solution containing 0.463 g/L U (VI) was achieved with 98% efficiency. Radiation stability of the ligands were studied by irradiating them at the gamma irradiation facility of IGCAR, Kalpakkam and it was established that the efficacy of the adsorbents was not affected due to irradiation. Considering the physical form and practical applicability, polymeric ligand is more suitable than the powder form and hence can be directly employed for the recovery of uranium from alkaline leach liquor.

7.9.5 Remediation of Radioactively Contaminated Soil and Water using Phyto-remediation Technique

Phyto-remediation is emerging as an alternative technology to high-cost energy intensive conventional methods. For the present study, certain plant species were initially screened and feasibility of Cesium (Cs) and Strontium (Sr) removal through hydroponic experiments was established. From the plant species which showed good promise in hydroponic experiments, few selected ones were considered for phyto-remediation studies for removing Cs and Sr from soil. Further, soil samples were collected from different NPP sites to find out the type of plant species that can grow in the type of soil prevalent at each site. The soil is being characterized extensively before a few plant species are shortlisted for the removal of radioactive Cs and Sr for each given NPP site. The studies on Remediation of Soil using Phyto-remediation were carried out in collaboration with CSIR-Institute of Minerals & Materials Technology (IMMT) at Bhubaneswar, Odisha as part of AERB Safety Research Programmes under Grant-in-Aid Scheme.

7.9.6 Synthesis and Characterization of Novel Ceramic Materials for Dosimetry Applications

Cerium doped strontium borophosphate glasses were prepared in-house, characterized, and studied for assessing their suitability towards dosimetry applications. In order to investigate the Thermally Stimulated Luminescence (TSL) mechanism of γ-irradiated Ce-doped glass samples, their TSL emission spectra were recorded. TSL of γ-irradiated (40 Gy) Cerium doped strontium borophosphate glasses showed a broad glow peak around 629 K. TSL intensity increased with the increase in Ce-concentration up to 0.5 mol% and beyond that it

decreased. The dose-response of 0.5 mol% Cerium doped strontium borophosphate glasses was studied in the dose range of 100 mGy to 10 Gy, which showed that TSL intensity increases with the increase in a dose up to 10 Gy. TSL trap parameters such as trap depth, frequency, symmetry, and the order of kinetics were determined to explore the dosimetric properties of the material.

7.9.7 Methodology for Estimation of Dose to Sewage Workers due to Active Liquid Effluent

Active liquid waste discharged to municipal sewage system from hospital, industries and research institutions may give rise to radiation exposure to a sewage worker. The sewage treatment processes (e.g. Physical, chemical and biological treatment) are carried out in different chambers of Sewage Treatment Plants (STP). During the treatment process Radionuclides gets distributed in water, sludge and sediment in STP. A sewage worker may get exposed to external radiation from stored sediment or internal radiation through inhalation of re-suspended particles from sediment. Primary sedimentation, biological treatment to decompose organic material, secondary sedimentation, thickening of sludge and sedimentation are main processes involved in an STP. Simulation of radionuclide transport between compartments in an STP is carried out by developing mechanistic model involving rate equations and mass balance. Mass balance of the desired radioactive isotope is done through dynamic model having system of ordinary differential equations. A computer code CARD (i.e. Compartment Analysis of Radiation Dose) was developed using fourth order Runge-Kutta numerical method. A case study was formulated with a typical STP with Biological Oxygen Demand (BOD) and Total Solid Suspended (TSS) to be 20 mg/l and 50 mg/l, respectively. The simulation was carried out and radiation dose received by a sewage workerworking at sediment processing area for a year due to both external exposures from sediment and inhalation of re-suspended particle from sediment was estimated.

7.9.8 Optimizing the Parameters of Borophosphate Glass Matrices for Waste Immobilization Applications

Vitrification is a proven technique for handling High Level Liquid Waste (HLLW), wherein the HLLW is mixed with glass and the vitrified canisters are stored in air cooled underground facilities. At present, borosilicate glasses are being used as the waste host matrix. However, it has disadvantages like thermodynamic instability and low and intermediate waste loading issues. Alternate matrices such as borophosphate glasses were studied for assessing their suitability in waste immobilization applications. Borophosphate glasses doped with CeO_2, Nd_2O_3, Gd_2O_3, UO_2, and Dy_2O_3 were prepared by the conventional melt quenching technique.

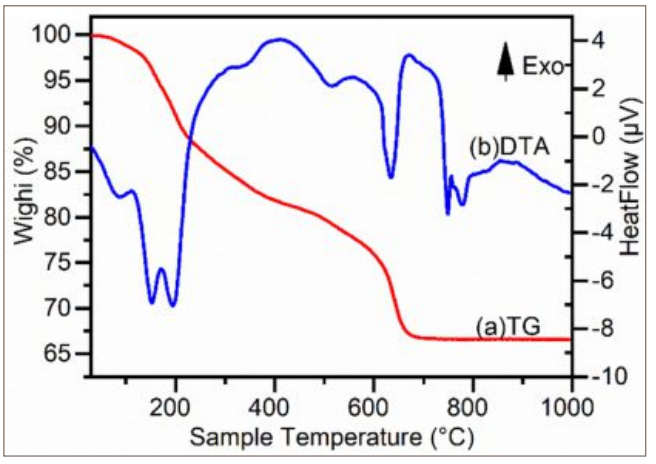


Figure 7.9.8.1 : (a)TG (b) DTA Analysis of Li_2O-ZnO-SrO-B_2O_3-P_2O_5 Glass Precursor

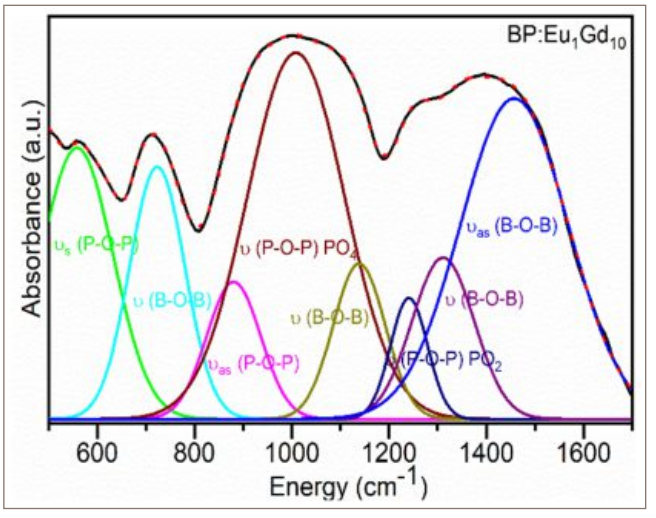


Figure 7.9.8.2 : Deconvoluted FTIR Spectra of Europium and Gadolinium Co-doped Glasses

The amorphous nature of the prepared SBP glasses was confirmed by XRD patterns. The Scanning Electron Microscopy coupled with-Energy Dispersive X-ray (SEM-EDX) was used to study the uniform distribution of elements in the glass matrix. The presence of phosphate and borate groups in the prepared glasses was ascertained by the FTIR and Raman spectra. Thermal properties derived from differential thermal analysis (DTA) and thermogravimetric (TG) analysis show good glass-forming ability and stability of prepared glasses (Figure 7.9.8.1 & 7.9.8.2). The leaching properties of prepared glasses were studied by adopting ASTM standard technique, and results show the prepared glasses are chemically stable. The results also reveal that doped borophosphate glasses are potential candidates for vitrification applications with their stability and glass-forming ability.

7.10 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 did not recommended any new projects. It also approved the renewal/extension of six ongoing projects. Thedetails are given in Tables 7.29.

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. But due to COVID 19 lock down restrictions, financial assistance was provided to only two programs.

Table 7.29: 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

CHAPTER 8

INITIATIVE FOR ENGAGING WITH STAKEHOLDERS AND PUBLIC

CHAPTER 8 - INITIATIVE FOR ENGAGING WITH STAKEHOLDERS AND PUBLIC

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 maintains its website with all relevant and updated information; issues press releases on issues related to nuclear and radiation safety, publishes quarterly newsletters, annual reports / bulletins etc.

8.1 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 all the news items related to nuclear and radiation safety published in various newspapers, magazines and on the web and provides its response as required. AERB also routinely responds to queries obtained through AERB website.

8.2 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 nuclear power plants including validity of operating licence, regulatory inspections, significant events, radioactive effluent discharges, occupational exposures etc. are provided on AERB's website and the information is updated on monthly basis.

AERB publishes e-Newsletter in English and Hindi on quarterly basis which are uploaded on the website.

During the COVID-19 pandemic also, AERB reached out to public and its various stakeholders through the virtual platform.

8.3 STRENGTHENING OF REGULATORY INTERFACES

8.3.1 National Investigation Agency (NIA)

AERB coordinated with the officials of National Investigation Agency (NIA) through the Office of IG (Security), DAE during the investigation of incident involving selling of 7 kg of Natural Uranium in Mumbai. This incident was intimated to the Incident and Trafficking Database (ITDB) of the International Atomic Energy Agency (IAEA).

8.3.2 Ministry of Chemicals and Fertilizers (MoCF)

AERB participated in the Inter-ministerial meetings held under the aegis of Dept. of Pharmaceuticals (DoP), Ministry of Chemicals and Fertilizers (MoCF) to discuss the predictable regulatory pathways for inclusion of medical devices for current and future notifications.

8.3.3 National Health Authority (NHA)

AERB continues co-ordination with the National Health Authority (NHA) to participate in the Government's National Digital Health Mission (NDHM) for an integrated digital health infrastructure. AERB endeavours to integrate its regulatory process associated medical radiation facilities in AERB's web-based licensing system (e-LORA) with Health Facility Registry (HFR) module of NDHM.

8.3.4 Ministry of Health and Family Welfare

Optimization of medical exposures is one of the important requirements for radiation safety of

patients undergoing diagnosis/therapy. Towards this, AERB coordinated with MoHFW on control and monitoring of medical exposures and extended its support to address the issue. It was also suggested to give priority for establishment of national Diagnostic Reference Levels (DRLs).

For regulation and maintenance of standards of education and services by allied healthcare professionals and other matters connected therewith, the Govt. of India vide gazette notification dated September 21, 2021, has constituted an Interim Commission under the recently enacted National Commission for Allied and Healthcare Profession Act 2021. Head, DRA&C, AERB is a Member of the Commission.

8.3.5 Ministry of Commerce and Industry

AERB is contributing through the inter-ministerial coordination committee in carrying out technical review of applications referred by Director General of Foreign Trades (DGFT), Ministry of Commerce and Industry (MoCI) for approval / renewal of "Recognition" in respect of Pre-Shipment Inspection Agencies (PSIA). These "Recognised" PSIAs from DGFT are responsible to undertake radiation surveys of consignment containing metal scraps and provide certificate that the consignment is free from presence of radioactivity.

8.3.6 Department of Atomic Energy

Government of India is considering accession to the 1996 protocol (London Protocol) to the Convention on Prevention of Marine Pollution by dumping of waste. MoEF&CC has initiated inter-ministerial consultations to prepare country's position on the same. Towards this, AERB has provided its views to DAE on the provisions of the protocol concerning marine discharge/disposal of radioactive wastes.

AERB continued to interact with DAE on issues related to control over Beach Sand Minerals and handling of other Naturally Occurring Radioactive Materials (NORM) such as Columbite Tantalite ores.

8.3.7 Central Pollution Control Board

AERB interacted with Central Pollution Control Board (CPCB) in the inter-ministerial meeting held on October 18, 2021 and provided inputs from radiological safety considerations towards development of guidelines on management of red mud produced from processing of aluminium bearing bauxite ore in the country.

8.3.8 Directorate General of Factory Advice Service & Labour Institutes (DGFASLI)

AERB interacted with Directorate General of Factory Advice Service & Labour Institutes (DGFASLI) and provided necessary inputs and clarifications towards development of standards under the Occupational Health Safety & Working Conditions Code with respect to handling of radioactive substances in factories.

8.4 SAFETY PROMOTIONAL ACTIVITIES

AERB organizes and/or participates in discussion meetings and other professional meets to deliberate on nuclear and radiation safety aspects and the system of regulatory regime followed by AERB and the basis of regulatory decision making process. AERB also organises safety promotional activities, the details of such events are given in the following paragraphs.

8.4.1 National Conference on Regulatory Interface (NCRI)-2021

AERB hosted a one-day National Conference on Regulatory Interface (NCRI) on November 11, 2021 at Mumbai. The theme of the conference was "Self-Regulation for Safety". The objective of the NCRI-2021 was to provide a platform to exchange views of the Licensees on self-regulation practices for ensuring safety, the initiatives perpetrated, and the way forward. A key attribute that has emerged during pandemic period, is the orientation of licensees towards "Self-regulation" through active involvement of its in-house resources viz. Technical audit engineers, Quality Assurance experts, Radiological safety officers, Industrial and Fire Safety professionals etc. Two major Licensee organisations viz. Nuclear Power Corporation of India Limited and Heavy Water Board were invited to present their experiences for NCRI-2021. The conference was organised in hybrid mode. The session consisted of talks on experiences in self-regulation practices in HWPs, Operating NPCIL plants & projects and their Remote Regulatory Inspection, by senior management of the respective organisations. 120 plus participants attended the conference.

Shri C. S. Varghese, Executive Director, AERB addressing during NCRI

Participants attending NCRI-2021 through Video Conferencing

Welcome Address by Shri A. P. Garg, Director, NFRG during NCRI-2021

Shri G. Nageswara Rao, Chairman, AERB delivering Inaugural Address

Delegates attending the Theme Meeting

8.4.2 Theme Meeting on Computer Codes: Status of Indigenous Development

To commemorate AERB's contribution in nation building and celebrating 'Azadi Ka Amrit Mahotsav', a Theme Meeting on “Computer Codes: Status of Indigenous Development” was organized on 21st December 2021 at AERB. The theme meeting aimed at taking stock of computer codes (relevant to nuclear safety) available in DAE units and AERB, status of relevant indigenous development, validation matrix, quality assurance plan, code and data preservation practice as well as future plans. More than 100 engineers/scientists/professors from utilities, R&D

organizations, elite educational institute and regulators from India involved in safety analysis and related computer code development attended this Theme Meeting organized in hybrid mode (online and offline). Online platform helped in reaching and connecting wider enthusiastic participants and experts ensuring abidance with current COVID-19 protocols/SOPs.

Shri S. B. Chafle, Director, NSARG addressing the Audience

Shri Avinash J. Gaikwad, Head, ERSD, addressing the Audience

The talks were delivered by invited experts from constituent DAE units, AERB and IITs who have developed expertise in safety analysis and researchers & scientists who were instrumental in development of computational tools for nuclear safety. Theme meeting was set in motion with visionary views from Shri C. S. Varghese, Executive Director, AERB and Shri G. Nageswara Rao, Chairman, AERB. Subsequently Three Technical sessions were held with talks from eminent experts in computer codes used in safety analysis and indigenous developments. Shri S. S. Bajaj, Former Chairman, AERB gave directions for future in the area of indigenous safety analysis computer code development.

8.4.3 E-Symposium on 'Roles and Responsibilities of Competent Persons Designated Under Various Sections of the Factories Act, 1948'

The Competent Persons under various sections of the Factories Act, 1948 are designated by AERB, based on their qualification and experience in line with the requirements specified in the Atomic Energy (Factories) Rules, 1996. They are responsible for ensuring that equipment/systems are tested and maintained as per statutory requirements. Competent persons along with safety officers have a great role to play in ensuring safety at work place.

To improve awareness among competent persons designated under various sections of the Factories Act, 1948, at DAE units, AERB has initiated a series of E-Symposiums on "Roles and Responsibilities of Competent Persons". These symposiums are aimed at educating the competent persons about their roles & responsibilities while carrying out testing, examination & inspection of various equipment/systems in the factory for ensuring their safe service as per the statutes. The E-Symposiums are being conducted on video conferencing platform. Three E-Symposiums have been organized till date. In these symposiums, regulatory perspective about responsibilities to be performed by the competent persons were explained along with relevant operational experiences. These E-Symposiums have provided a platform for sharing the best practices implemented while carrying out tests, inspections and examinations of various systems, equipment and components. Around 400 officials from various DAE units (NPCIL, BARC, IGCAR, HWB, NFC, UCIL, etc.) had attended these Symposiums.

8.4.4 37th DAE Safety & Occupational Health Professionals Meet

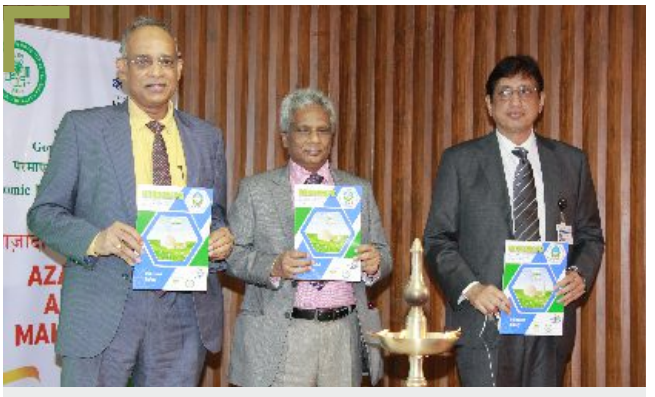
The 37th DAE Safety & Occupational Health Professionals Meet, 2021 was jointly organized by AERB and IREL (India) Limited during October 08-09, 2021 in hybrid mode. The themes of this meet were "Self-regulation for Safety" related to industrial safety aspects and "Challenges and Opportunities in Occupational Health during COVID-19 Pandemic" related to occupational health aspects.

Due to the prevailing pandemic situation and imposition of corresponding protocols, DAE Safety & Occupational Health Professionals Meet was

organized through online platform and also at Niyamak Bhavan, AERB with restricted attendance of officials from DAE units. Around 200 delegates from various DAE units & aided institutes, participated in the meet through online platform. During the meet, technical sessions were held on industrial safety & occupational health, in which distinguished persons from the field of industrial safety and occupational health were invited to deliver lectures on the topics relevant to the respective themes. These lectures were immensely helpful in knowledge enrichment of the participants. The meet provided platform to professionals for interactions and sharing the experience in the areas of industrial & occupational health safety.

Dignitaries inaugurating the Safety Meet by Lighting the Lamp (Prof. A.K. Mohanty, Director, BARC, Shri G. Nageswara Rao, Chairman, AERB, Shri D. Singh, CMD, IREL (India) Ltd. and Shri V. Chandrasekar, DGM & OIC, IRERC)

Shri G. Nageswara Rao, Chairman, AERB delivering the Keynote Address



Dignitaries releasing the AERB Booklet on Occupational Injury Statistics and Fire Statistics of DAE Units for the year-2020

Shri C. S. Varghese, Executive Director, AERB addressing 37th DAE Safety & Occupational Health Professionals Meet

Delegates Attending the 37th DAE Safety & Occupational Health Professionals Meet

8.4.5 Webinar Series for Sharing of Operating and Regulatory Experiences on Significant Events in Indian NPPs

Operating experience provides valuable insights for improving the safety of Nuclear Power Plants (NPPs). India has more than 50 years of experience of operating the NPPs. Over the years, NPPs in India had experienced certain safety significant events which played vital role in shaping the Indian Nuclear Industry in various aspects ranging from design to safety regulations. These events provide valuable safety insights, learnings & knowledge, which need to be continuously utilized by various stakeholders in different stages of lifecycle of NPPs and transferred to young nuclear professionals.

Considering that these events had occurred many years or decades ago, maintaining knowledge on these events among the licensees and regulatory body is a critical challenge. Hence, AERB has identified 29 safety significant events occurred in Indian NPPs for discussions and organized a series of webinars on these events from July 2021 to February 2022. So far, 21 webinars have been conducted in the presence of 350 officials from participating organizations i.e. NPCIL-HQ, BHAVINI, NPP/projects, HWB, BARC, IGCAR and AERB. In these webinars, officers from NPPs/AERB, who have good knowledge on the events by virtue of their involvement in event handling, review or analysis delivered the presentations. The webinars provided platform for sharing operation & regulatory experiences on these events among various stakeholders and also facilitate transfer of knowledge to next generation of designers, analysts, operators, internal reviewers and regulators to further improve their skill and competence. The webinars are also being utilized as an instrument for archiving important event related information, developing digital training materials (including recorded videos on presentations) for future generation and preparation of a booklet on 'Operating and Regulatory Experiences from Safety Significant Events in Indian NPPs'.

Webinar Series for Sharing of Operating and Regulatory Experiences on Significant Events in Indian NPPs

Delegates attending Webinar on Sharing of Operating and Regulatory Experiences on Significant Events in Indian NPPs

8.5 PUBLIC AWARENESS ACTIVITIES

8.5.1 Participation in Public/Scientific Events

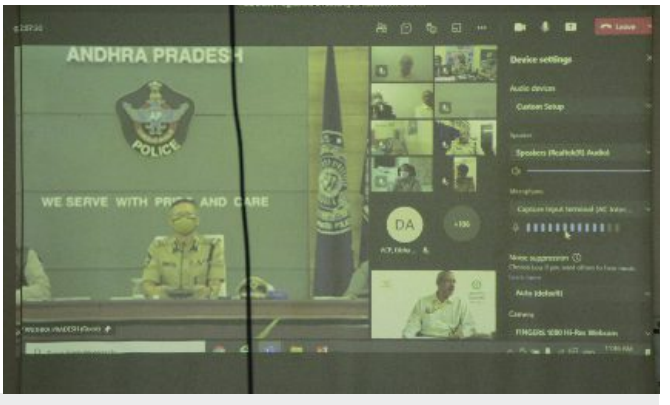
In view of Covid-19 restrictions, public communication activities through online forums were continued.

AERB conducted a webinar on July 7, 2021 on 'Societal Benefits of Radiation Technology and Safety Aspects' for institutions of higher education in Guwahati and stakeholders of radiation facilities possessing radioactive sources in Assam.

AERB Conducted Webinars on 'Security of Radioactive Sources' for Gujarat and Andhra Pradesh Police Personnel on February 02, 2021 and November 10, 2021 respectively to spread awareness on radiation safety and regulations. Representatives of radiation facilities using Category-1 and 2 radioactive sources also participated in the webinar. The objective of the webinar was to bring the law and enforcement authorities and representatives of the radiation facilities on a common platform to disseminate requirements for ensuring security of radioactive sources and apprise the role of law and enforcement authorities. Around 130 and 150 participants participated in the webinar conducted for Gujarat and Andhra Pradesh Police respectively.

Shri G. Nageswara Rao, Chairman, AERB, delivering the Inaugural Address during Webinar organised by AERB for Gujarat Police on February 02, 2021

Dr. Rajdeepsinh Jhala, Superintendent of Police, Valsad, Gujarat, Shri Anand Pinjarkar, DRA&C, AERB, Dr. A. U. Sonawane, Head DRA&C, AERB and Shri Sanjay Kumar, Director (Security and Coordination), DAE during the Webinar organised for Gujarat Police on February 02, 2021.



Shri G. Nageswara Rao, Chairman, AERB, Shri D Gautam Swang, DGP (AP), Shri Vinayak Apte, IG (Security), DAE, during the Webinar organised for Andhra Pradesh Police on November 10, 2021

8.5.2 AERB Participated in the Following Forums:

(i) Online Summit on Radiology Imaging held on June 23, 2021 wherein AERB officer delivered message on emerging technologies in the field of medical X-ray imaging, importance of radiological safety and need on optimisation of medical exposures. Around 500 participants participated in the summit.

(ii) School of Allied Health Services, Vinayaka Mission's Research Foundation, Salem, Tamil Nadu organised a national level webinar on Radiation Safety & Protection in Diagnostic Radiology, Nuclear Medicine and Radiotherapy on August 07, 2021. 1,468 Students, Imaging Technologists, Teaching faculties and Physicians all over India participated in the webinar. AERB officers delivered the keynote address and informative talk in the webinar.

(iii) MGM Hospital, Navi Mumbai conducted on-line awareness programme on November 12, 2021. AERB officer delivered lecture on the safety aspects in the use of different modalities of X-ray equipment. 25 students of X-ray Radiography and Interns of Radiology Department participated in the programme.

8.5.3 Release of AERB's organizational brochure

Informative organisational brochure of AERB was released by AERB Board members as part of 'Azadi Ka Amrit Mahotsav' celebrations on the Annual Day function held on November 26, 2021. The brochure has been brought-out for distribution among delegates of AERB and stakeholders during safety promotion events.

Awareness Competitions at Schools/Colleges

To commemorate the 75th year of India's Independence AERB has joined the year-long celebrations of 'Azadi Ka Amrit Mahotsav' and conducted various awareness and scientific events and competitions. The awareness cum competition programmes were conducted at a government school at Amarut village, Gaya, Bihar, and RM School and Oriental College, Imphal.

Glimpses of 'Azadi Ka Amrit Mahotsav' Programme conducted by AERB at Oriental College, Imphal, Manipur on November 13, 2021

8.6 COORDINATION WITH MINISTRY OF HEALTH AND FAMILY WELFARE

AERB Officers delivered a talk on "Regulatory Requirements and Safety in Diagnostic Radiology" organized by National Health Systems Resource Centre (NHSRC), Ministry of Health and Family Welfare. Also, they participated as panelists in the National Level virtual review in the workshop.

8.7 JOINT CONSULTATION MEETING

(i) AERB conducted a virtual Joint Consultation Meeting (JCM) on July 22, 2021, with an objective to finalise revised Off-Site Emergency Exercise (OSEE) framework which has been systematically evolved over the past few years. The JCM was attended by representatives from AERB, National

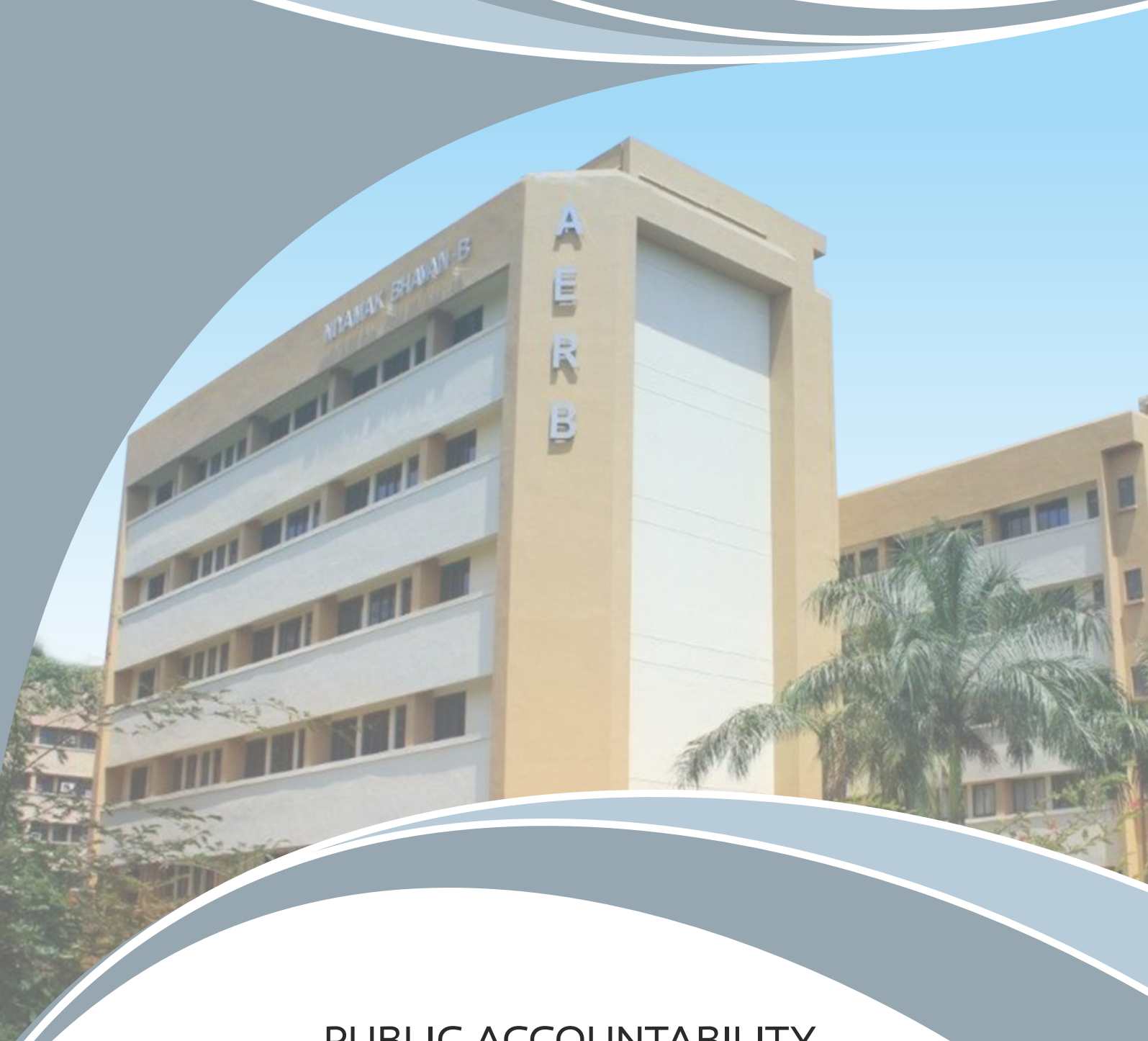
Disaster Management Agency (NDMA), Crisis Management Group, DAE, BARC and NPCIL. The stakeholders' agreed to the revised OSEE framework.

(ii) Inter-ministerial virtual meeting with Directorate General of Foreign Trade (DGFT)

AERB continued the Inter-Ministerial coordination activities by carrying out review of applications, referred by Director General of Foreign Trades (DGFT), Ministry of Commerce and Industry (MoCI) for approval/ renewal of "Recognition" in respect of Pre-Shipment Inspection Agencies (PSIA) by verifying the technical details of Radiation Survey Meters and Nuclear Identifiers. These "Recognised" PSIAs from DGFT are responsible for conduct of radiation surveys of consignment containing metal scraps and provide certificate that the consignment is free from presence of radioactivity.

During the period, one virtual meeting was held on August 27, 2021 to recognize PSIA for issuance of PreShipment Inspection Certificate (PSIC) to imported metal scraps in India.

CHAPTER 9



PUBLIC ACCOUNTABILITY

CHAPTER 9 - PUBLIC ACCOUNTABILITY

9.1 GRIEVANCE REDRESSAL

AERB receives grievances through Centralised Public Grievance Redress and Monitoring System (CPGRAMS) portal which includes Department of Atomic Energy (DAE) and Prime Minister's Office (PMO). All grievances pertaining to AERB were duly responded in time.

9.2 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 has become a statutory right of every citizen. 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.

AERB received a total of 142 RTI requests during the year 2021. Year wise RTI queries replied by AERB during the last four years and 2021 are given in Figure 9.1.

The frequently asked questions under RTI were compiled and uploaded on AERB website for reference of the public.

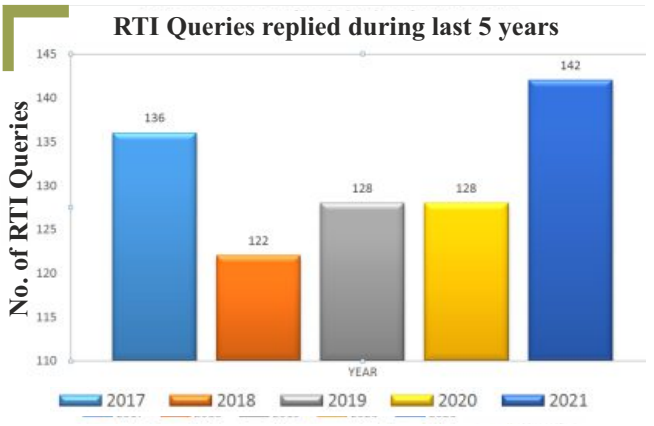


Figure 9.1: RTI Queries replied during last 5 years

9.3 PARLIAMENTARY QUESTIONS

During the reporting period, AERB submitted responses to 54 of the parliamentary questions related to regulation of nuclear and radiation facilities. The questions answered with implications to radiation safety were broadly classified under seven issues as below:

AERB responded to 54 parliamentary questions. The questions answered with implications to radiation safety were broadly on the issues as shown.

- Safety of Nuclear Power Plants
- Nuclear Waste Management Policy
- Radiation Therapy Centres for Cancer Treatment
- Public Health Hazard of Uranium Mines
- Health and Safety of Labourers
- Contamination in Ground Water
- Administrative Issues

CHAPTER 10

INTERNATIONAL CO-OPERATION

CHAPTER 10 - 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 2005 Amendment, Convention on Assistance in the case of Nuclear Damage and Radiological Emergency, Convention on Early Notification of Nuclear Accident etc. India is also committed to implement the provisions of Code of Conduct on safety of research reactors and code on 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 International Atomic Energy Agency (IAEA) and Nuclear Energy Agency (NEA).

AERB has bilateral cooperation arrangement with the regulatory bodies of several countries for information exchange and experience sharing related to regulation of nuclear and radiation safety. AERB has bilateral arrangements with the nuclear regulatory authorities of France, Russia, Ukraine, the United States of America, Finland, Canada, Bangladesh, the United Kingdom and Vietnam.

Some of the important activities undertaken under the multilateral and bilateral international cooperation activities during the year are described in the following paragraphs.

10.1 STRENGTHENING NUCLEAR SAFETY AND SECURITY

10.1.1 IRRS Extended Follow-up Mission

Owing to the pandemic situation and the restriction around the world, IAEA proposed revised dates for the IRRS Extended Follow-up Mission to India to year 2022.

10.2 BILATERAL INTERNATIONAL COOPERATION

10.2.1 Renewal of the Bilateral Arrangement between AERB and ASN

The Bilateral Arrangement between the Nuclear Safety Authority (ASN) of France and Atomic Energy Regulatory Board (AERB) for the exchange of technical information and cooperation in the regulation of nuclear safety and radiation protection was renewed on September 21, 2021. The Arrangement was signed by Chairman ASN and Chairman, AERB in a side-line meeting held on the margins of IAEA General Conference in Vienna. The Arrangement will remain in force for five years.

Glimpse of Bilateral Delegation Meeting

10. 2.2 Meeting between AERB and US DoE's ORS

A virtual meeting between Office of Radiological Security (ORS) of US DoE and AERB was held on October 05, 2021. This meeting was organized as a follow up to the meeting held between ORS and AERB delegation on January 30, 2020 during the AERB delegation's visit to USNRC for annual bilateral meeting. The discussion held in this virtual meeting primarily focused in the areas of safety and security of radioactive sources. Possible areas for future collaboration were also discussed in the meeting.

10.2.3 AERB Participated in the Joint Committee Meeting (JCM) between India and Vietnam

AERB participated in the 2nd JCM between Vietnam and India held virtually on March 18, 2021. AERB's support to VARANS (the nuclear regulatory body of Vietnam) in reviewing applications for siting, construction and operation Licence of the new research reactor was discussed. VARANS and AERB expressed desire to have more interactions under the existing bilateral framework.

10.3 PARTICIPATION IN INTERNATIONAL MEETINGS/SEMINARS

(a) Shri G. Nageswara Rao, Chairman, AERB attended the 65th General Conference of the International Atomic Energy Agency (IAEA) held during September 20-24, 2021 at Vienna, Austria as a Member of Indian delegation led by Shri K.N. Vyas, Chairman, Atomic Energy Commission. On September 23, 2021 Chairman, AERB attended the Senior Safety and Security Regulators' Meeting.

(b) Chairman, AERB also participated in bilateral meetings with ASN (nuclear regulatory body of France), USNRC

(c) Five officers participated in the IAEA consultancy meeting on 'Review of Applicability of Safety Standards to Novel Advanced Reactors - Part I, II and III' held on March 15-19, May 17-19 and July 12-16, 2021.

(d) AERB Officers actively participated in the Following Meetings.

(i) International Meetings/Webinars/Training Programmes through virtual mode: Indo-US-UK "Virtual Technical Exchange program on Security by Design for Devices and Facilities that use Radioactive Materials" organized by GCNEP, Bahadurgarh.

(ii) IAEA Consultancy meeting on the Review of Applicability of Safety Standards to Novel Advanced Reactors (Part III), during July 12-16, 2021.

(iii) Online Atomic Energy Research (AER) Working Group meeting on 'International benchmark exercise for VVER Reactor Pressure Vessel (RPV) and fuel assembly coolant mixing".

(iv) As member of MDEP VVER TESG on Severe Accidents, AERB officers attended meeting for preparation of technical report on long term heat removal from the containment.

(v) The IAEA CANDU PSA Working Group (CPWG) organized a virtual "Technical Meeting of the CANDU Probabilistic Safety Assessment Working Group", during 25th to 29th October 2021. AERB officials participated in the CPWG meeting and contributed in the preparation of an IAEA Technical Document titled, "Level-2 Probabilistic Safety Assessment Practices for NPPs in countries operating CANDU-type Reactors".

Shri G. Nageswara Rao, Chairman, AERB, Dr. A. K. Mohanty, Director, BARC and Shri K. N. Vyas, Chairman, AEC during 65th IAEA General Conference

CHAPTER 11

HUMAN RESOURCES DEVELOPMENT AND INFRASTRUCTURE

CHAPTER 11 - HUMAN RESOURCES DEVELOPMENT AND INFRASTRUCTURE

11.1 MANPOWER AUGMENTATION

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

The total sanctioned strength in AERB is 468. However, in-position strength as on December 31, 2021 is 350 comprising of 304 Scientific & Technical and 46 Administrative/Accounts/Auxiliary staff. During the period, five scientific officers in the grade of SO (C) from BARC and IGCAR Training Schools have joined AERB. One Technical Officer has joined through direct recruitment.

11.2 IMPLEMENTATION OF PERSONS WITH DISABILITIES

11.2.1 Implementation of Persons with Disabilities (Equal Opportunities, Protection of Rights and Full Participation) Act, 1995 and Implementation of Reservation Policy for Scheduled Castes/ Tribes/OBC

There is one backlog vacancy in 'Person with Disabilities Quota' due to resignation of a Lower Division Clerk (LDC) on July 31, 2017. Rosters are maintained as per the orders on the subject. The backlog vacancies are being worked out and periodic reports and returns are sent to DAE.

11.3 INTEGRATED MANAGEMENT SYSTEM

Consequent to the IAEA's IRRS Mission in 2015, AERB had initiated a programme to strengthen its processes and concurrently develop and integrate all the internal procedures for its coherent functioning. Necessary changes in its organisational structure were also made to address clear demarcation in roles and responsibilities for important functions like regulatory inspection, public communication and emergency preparedness and independence in decision making. This step facilitated better understanding of interfaces of regulatory processes and thereby helped in development of formal IMS and also fulfilling all the applicable requirements from IAEA's GSR Part-2.

The IMS of AERB brings all the multiple, interrelated and interacting processes required for the above functions into single framework. IMS of AERB integrates all of AERB's systems and processes into one complete framework, enabling it to work as a single unit with unified objectives. It addresses regulatory aspects of both i.e. safety and security related to nuclear and radiation safety in an integrated manner. It is meant for effective conduct of various regulatory processes that help in achieving the mission, goal and objectives of safety, health, protection of environment, security and quality. The IMS was initially adopted by AERB in May 2018 with approval of the Board.

The experience gained with the implementation of IMS for over two years and the feedback received indicated the need for certain modification, updating and rearrangements in IMS Level-1 document i.e. top level document for more coherent operation of various processes. The revision addresses (1) rearrangement of organisational policies and aligning elements of organisational strategy with them; (2) Including process governing policies which come under purview of the Board; (3) Spelling out strategies necessary for supporting regulatory processes; (4) Incorporating a chapter on systematic approach for decision making; and (5) Providing more clarity on (a) audit of IMS implementation and (b) Self-assessment of individual processes. The delegation of decision making authority to the Secretariat and the multi-tier review levels are in accordance with the past decisions of the Board and in line with AERB's safety documents on consenting process for nuclear and radiation facilities.

Further, with the availability of International Atomic Energy Agency (IAEA) documents on "Organisation,

Management and Staffing of the Regulatory Body for Safety, GSG-12" and "Functions and Processes of the Regulatory Body for Safety, GSG-13", AERB undertook a comparative study of its IMS with those IAEA documents. The Level-1 document of IMS was revised addressing the gap areas identified by this mapping and also the feedback received.

This document will help in promoting a consistent approach to fulfil AERB's regulatory mandate accomplishing the mission, vision and goals. The revised IMS Level-I document was issued for regular use on February 28, 2021.

AERB's integrated management system is implemented through a series of easily understandable documents arranged in three levels of hierarchy based on modular approach considering the distributed responsibility and ease in implementability. In order of the significance and role of the documents in shaping the management system, various IMS documents are categorised as follows:

i. IMS L-I: It covers Mission, Vision, Mandate, overall organizational policies and strategy, regulatory processes including governing policies, strategies supporting regulatory processes, management processes, matters related to office administration, organisational structure and delegation of responsibilities and authorities.

ii. IMS L-II: In order to meet the expectations laid down in IMS-level I, level-II documents are framed as follows:

a) Level-IIA: provides strategies, plans and interfaces for core and associated regulatory processes; policies, strategies and plan for management processes

b) Level-IIB: provides strategies, protocol and guidelines in support of regulatory processes.

c) Level-IIC: provides procedures for office administration and related activities common to entire organisation.

iii. IMS L-III: It covers procedures, work-plans, checklists, etc. for implementation of processes as identified in respective L-II documents.

IMS documents are managed and controlled in specified manner so that they are readily available at the point of use and also future reference.

Independent assessment was carried out with respect to implementation of IMS in AERB through internal audit. All units at AERB HQ were audited and reports containing observations/recommendations for each unit was issued.

11.4 TRAINING

As part of competence development, AERB continued to train its staff by organizing training programmes, workshops, on-job-training (OJT) at nuclear and radiation facilities, refresher training courses, technical talks, colloquia and participation in national and international programmes. AERB also provides Internship Training to the students of various academic institutes as a part of CSR activities.

11.4.1 Manpower Induction and Training of AERB Staff/Initial Training Programme for New Recruits

Orientation Training Programme for 10 new Trainee Scientific Officers (TSOs) and 16 new Scientific Assistants were conducted.

11.4.2 On-the-Job Training (OJT)

On-the-job training of 14 AERB officers at various NPP sites viz. RAPS, TAPS, KKNPP were conducted where they get hands-on experience in NPP functioning.

11.4.3 Refresher Training on 'Containment Safety'

AERB conducted two refresher trainings on 'Containment Safety' comprising of 28 lecture series for the officials of AERB and NPCIL. The lecture materials of training course on 'Containment Safety has been up-loaded on AERB's knowledge management portal.

11.4.4 Refresher Training on 'Accelerators and their Safety'

Refresher training on 'Accelerators and their Safety' comprising of 10 lecture series was organised for the 29 participants from AERB. The lecture materials of

this training course has been up-loaded on AERB's knowledge management portal.

11.4.5 Technical Excellence Programme

In pursuit of excellence while performing the regulatory functions by AERB employees, a programme of Technical Excellence has been taken up at AERB. Technical Excellence Teams (TETs) were formed in AERB to develop resource materials in the expert area of the participants with the aim to capture tacit knowledge and sharing their work experiences. The resource materials would be utilized in skill enhancement and gaining knowledge by the other employees of the AERB.

The idea of TET initiative was originated in view of the Kaizen approach and its relevance for creating continuous improvement, based on the idea that small, ongoing positive changes can reap major improvements in enhancing organization efficiency. It was emphasized on team building and unidirectional team efforts for better results.

For technical knowledge centric organization like AERB, it was started with an objective of building team of technical excellence for facilitating knowledge enhancement, capturing and converting tacit knowledge into usable resource materials for competency building among AERB officers, involved in various areas of safety regulations.

The TET programmes provide a platform to young officers for sharing their knowledge. The participant

Shri G. Nageswara Rao, Chairman, AERB interacting with the TET Members in Virtual Mode

officers are supposed to take extra initiative in creating, sharing and utilizing knowledge through collective efforts. This programme has served very useful for AERB to discharge the mandated responsibilities, to enhance the employee competencies and to maintain high standards of performance in the organization. Around 77 projects have been identified and the presentations on 39 topics have been completed till date

11.5 KNOWLEDGE MANAGEMENT

11.5.1 AERB Colloquium/Technical Talk

AERB conducts technical talks/colloquia at regular intervals for its staff for knowledge upgradation. 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, legal aspects and aspects enhancing personal and interpersonal effectiveness etc.

The technical talks/colloquia on the following topics were organized:

(i) Safety Culture Assessment of AERB

(ii) Learning from-Accident Styrene Vapour Leakage

(iii) Introduction and use of TrueConf

(iv) Biological Aspect of Radiation Protection and System of Radiological Protection

(v) Biological Effects in Human Beings & Internal Dose Evaluation Model.

(vi) Sources of Radiation Exposure & Cellular Level Effects of Radiation

(vii) Security of Radioactive Material

(viii) Competence Acquisition and Development among Regulators

(ix) Knowledge Management

(x) Cyber Security Guidelines for AERB Employees

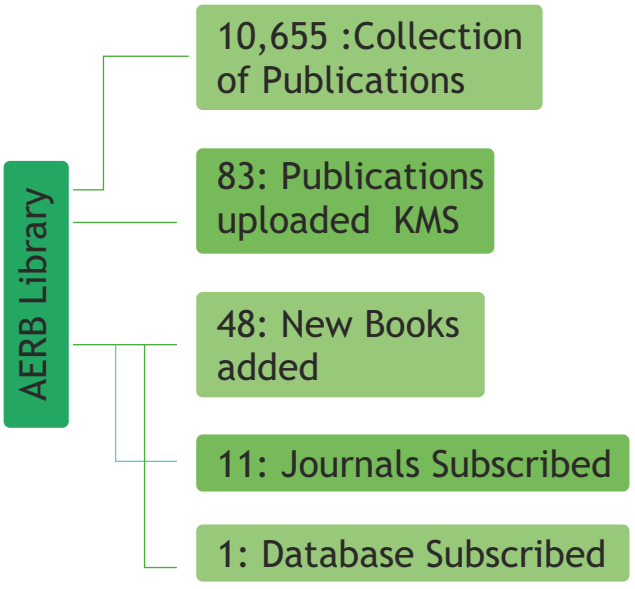
(xi) Objectives and the Process of IRRS

11.5.2 Knowledge Portal

A 'Knowledge Portal' 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 in the portal at regular intervals. AERB Codes/Guides/ Manuals have also been uploaded on the portal.

11.5.3 Scientific Information Cell

A well-equipped scientific information cell (Library) is maintained in AERB. Eighty-three publications were uploaded in Knowledge Management System (KMS). Around 48 new books have been added to the library. The total collection of publications in library has gone up to 10,655. In addition, 11 Journals and 1 Database were subscribed during the period. Reference and information services were provided to the users and visitors of the Library. World Nuclear News, IAEA Weekly News, NEA News Bulletin etc., were circulated in digital form regularly by sending e-mails to AERB staff. Table of Contents of new issues of important journals of AERB's subject interest were also circulated regularly through email alerts.



11.5.4 Promotion of Excellence in Human Resources

Smt. Ritu Jitendra Singh, SO/G, NSARG, AERB has been awarded Doctor of Philosophy (Ph. D.) degree from Indian Institute of Technology (IIT) Bombay, Mumbai for her thesis titled 'Effect of Roller Path and Constitutive Behaviour on the Residual Stress in a Pressure Tube Rolled Joint' in the 59th Convocation ceremony held on August 07, 2021.

Smt. Aarti Kulkarni Tripathi, SO/F, RSD, AERB has been awarded Doctor of Philosophy (Ph.D.) degree from Homi Bhabha National Institute (HBNI), Mumbai (constituent unit is Tata Memorial Centre, Mumbai) for her thesis titled 'Dosimetric and Quality Assurance studies in High Dose diagnostic imaging modalities to establish National Radiation Protection Programme'.

Shri Pradip Kumar, SO/F, DRI, AERB has been awarded Doctor of Philosophy (Ph. D.) degree from National Institute of Technology Raipur, Chhattisgarh for his thesis titled 'A Multi-Institutional Study on Dosimetric Quality Assurance in Advanced Radiotherapy Techniques' on 01 December 2021.

11.6 MAJOR ORGANISATIONAL CHANGES

Consequent to the superannuation of Shri D.K. Shukla, Executive Director, AERB and Chairman, SARCOP, Shri C.S. Varghese, Director, NFRG, AERB has been designated as Chairman, SARCOP and Executive Director, AERB w.e.f. March 01, 2021. As Chairman, SARCOP, Shri Varghese is the Ex-Officio Member of the Board of AERB.

Shri C.S. Varghese, taking over Charge as Executive Director, AERB

As part of re-organization of AERB for effective and efficient security regulation of nuclear and radiation facilities including computer security in NPPs and for effective functioning of legal cell to provide need based legal support for various regulatory processes as part of safety regulation of nuclear and radiation facilities and other activities, two separate cells 'Legal and Security Cell' are formed. The cells report to Executive Director, AERB.

Consequent to the retirement of Dr. L.R. Bishnoi, Director, NSARG on superannuation on August 31, 2021, following organizational changes were made with effect from September 01, 2021.

1) Shri S.B. Chafle, Head, NPSD designated as Director, NSARG.

2) Shri A.P. Garg, Head, OPSD designated as Director, NFRG.

In view of the new and emerging regulatory requirements related to advanced technology reactors, non-power reactors and long term operation and prioritization of research projects, a new Division called "Emerging Regulatory Strategy Division (ERSD)" was formed to cater to these requirements.

i) Shri Avinash J. Gaikwad, Head, NSAD designated as Head, ERSD and Head, R&DD.

ii) Shri S. Harikumar, Head, R&DD designated as Head, NPSD reporting to Director, NFRG.

iii) Shri J. Koley, Head, DRI designated as Head, OPSD reporting to Director, NFRG.

iv) Shri Utkarsh S. Chikkanagoudar, Head, LWR-FCF-PS, NPSD designated as Head, NSAD reporting to Director, NSARG.

v) Shri R.U. Parmar, Head, PHWR-PS, NPSD designated as Head, DRI reporting to Executive Director, AERB.

Consequent to the retirement of Dr. L.R. Bishnoi, Shri H. Ansari, Scientific Officer (H), was appointed as Part-time Vigilance Officer in AERB for a period of 3 years with effect from 01.02.2021 to 31.01.2024.

11.7 CONSTRUCTION/MODIFICATION AT AERB HQ AND REGIONAL CENTRES

11.7.1 Green Energy Initiative at AERB HQ

As part of a green energy initiative, AERB has installed a solar power plant with 25kWp on the available rooftop area of its Head Quarter Building, Niyamak Bhavan – A & B, Anushaktinagar, Mumbai. Rooftop Solar Power Plant was commissioned on September 09, 2021, and has been in operation since then. The above solar plant generated a total of 8070 units until December 31, 2021. In addition, as part of energy conservation, Niyamak Bhavan-A, all conventional luminaries, were replaced by LED lights this year.

11.8 INFRASTRUCTURE DEVELOPMENT

11.8.1 Information and Communication Technology (I&CT)

During the year, AERB continued it's functioning in the hybrid model through a judicious mix of physical interactions and web-based platforms for most regulatory activities, including safety review of nuclear and radiation facilities licensing and regulatory inspections. The functioning of organisation required seamless management of all I&CT services and upgradation of associated resources. To meet the requirements in special situations, I&CT infrastructure had to be monitored remotely and maintained on-premise using the essential human resource. Towards maintaining and improving I&CT infrastructure and services, following important installations of systems/up-gradation of existing systems were undertaken.

11.8.2 Up-gradation of Network Components of AERB WAN Interface

Up-gradation to the obsolete routers and network switches was completed for the AERB WAN interface (i.e. the interface connecting AERB LAN with the Regional Regulatory Centres at Chennai, Kolkata and New Delhi and Safety Research Institute - Kalpakkam). The devices were implemented in high availability mode so that failure of one device does not affect the entire system.

11.8.3 Audio-Visual and Video Conference System at AERB

A state of the art audio visual and video conference system was installed in new Board Room of AERB. The system has been implemented with two numbers of interactive display panels, video conference system and other audio and video accessories. Also,

the Executive Director's conference room has been upgraded with a new interactive display system and equipment for conducting online meetings through software based video conferencing systems. A video streaming software was also procured and implemented. This is mainly to video stream the public awareness programmes for Radiation Safety through video sharing platforms like YouTube.

11.8.4 Implementation of on Premise Video Conference Software

An on premise software based video conference system has been functional since last year. The online meetings of various committees of AERB are being conducted regularly through this platform. Also, Theme meetings, Lectures, Workshops, Farewell etc. are conducted through this system. During this year, the system has been implemented to various DAE units for conducting meetings.

11.8.5 Up-gradation of Internet Lease Line System at AERB

The MTNL Internet Leased Line has been upgraded from 10 Mbps to 150 Mbps. This upgraded line along with a leased line from TATA is implemented through a Link Load Balancer in high availability mode. This is implemented for the redundancy of the publicly hosted servers in case of failure of one line.

(i) Implementation of e-Office

The e-Office has been operational in AERB with the help of NIC (National Informatics Centre). E-Office modules ware upgraded to incorporate changes to improve the features and performance. The Personnel Information Management System was implemented. Catering towards complete employee life cycle management from recruitment to retirement. E-service Book can be generated using this system. Corrections/changes /upgrades in Leave Management System, Knowledge Management System and File Management System modules were performed.

(ii) Pay Roll, CHARMS/APAR System Implementation

The Payroll system software was kept up-to-date as per requirements specified by Accounts Section and suitably modified to accommodate the changes in the modules for Income Tax (IT) calculations as per the latest IT rules. Modifications in the attendance management software & CHARMS/APAR systems were carried out for generating reports from RFID based attendance management system for AERB employees and towards implementation of APAR.

11.8.6 Development of In-house Software Applications

Following application software have been developed in-house at AERB during this year:

(i) Application Program on Assessment for Authorization of Inspectors

(ii) Web Application on Divisional Monthly and Quarterly Report

(iii) Application for Managing Review of IAEA draft Safety Standards

(iv) Application for Monitoring of Capital Projects

11.8.7 Construction Work

Intending to decentralise its regulatory activities, AERB has established Regional Regulatory Centres (RRCs) at Chennai, Kolkata and New Delhi. In addition, the construction of a new office building also started in Niyamak Bhavan campus at the HQ. The progress of work is as follows:

(i) Southern Regional Regulatory Centre (SRRC), Chennai is already fully functional from the new building. Furniture and IT infrastructure were established at SRRC.

(ii) Civil construction of Eastern Regional Regulatory Centre (ERRC), Kolkata building is completed and likely to be occupied shortly after statutory clearance from local Government authorities is issued.

(iii) A new DAE office building is planned at Sector-9 Dwarka, New Delhi. Various DAE units like AERB, AMD, BRIT, NPCIL, ECIL, DAE secretariat units are proposed in this building with built-up area of about 12000 m^2. AERB's Northern Regional Regulatory Centre (NRRC) is planned in this building. The architectural concept plan of this building is in finalization stage.

(iv) Construction of Niyamak Bhavan-C building and development of parking area at HQ are in advance stage of completion.

(v) Meeting rooms & auditoriums of Niyamak Bhavan-A&B were upgraded. AERB Board Room was completely renovated. Since its inception, AERB Safety Research Institute at Kalpakkam has focused on theoretical R&D in key areas of nuclear safety. Four experimental facilities, namely Hydrogen Mitigation Facility (HYMIF), Water and Steam Interaction Facility (WASIF) Phase-I and II and Core Melt Retention Facility (COMREF) and Annular Gas Monitoring System (AGMS) Facility have been set up within the hall. In order to expand the infrastructure and provide facilities for collaborative experimental studies within DAE and with academic institutions, SRI Engineering Hall (Phase-II) is being set up adjacent to SRI Engineering Hall (Phase-I) under the DAE vision Scheme. It is envisaged that six different experimental facilities will be built within the hall in future in collaborative mode. Planning of the hall has been completed. The project is in tender evaluation stage and construction activities are expected to commence in year 2022.

(vi) The SRI Guesthouse was established in year 2003 and has been extensively utilized for stay of officials visiting Kalpakkam for official purpose and for conducting seminars, workshops and technical meetings. This guesthouse is being upgraded. The renovation and upgradation activities are being carried out by GSO Kalpakkam.

Installation of Solar Power Plant on Roof Top of Niyamak Bhavan - A&B, AERB at Mumbai

Construction in Progress for Niyamak Bhavan - C at Mumbai

11.9 AERB FORMATION DAY

AERB was formed in November 1983, and to commemorate 38th Formation Day of AERB, a function was organized on November 26, 2021. In view of the prevailing COVID-19 pandemic, this year's programme was conducted in a mixed mode (i.e. Physical and virtual mode through video-conferencing platform). The programme was held in Niyamak Bhavan Auditorium with a limited audience following Covid-19 protocols. Safety Research Institute, Kalpakkam, Southern Regional Regulatory Centre, Eastern Regional Regulatory Centre and Northern Regional Regulatory Centre attended the programme virtually. AERB Board Members were invited as the Chief Guests for the function. The Programme commenced with welcome address by Chief Administrative Officer, AERB, followed by inauguration with Saraswati Vandana, and lighting of the lamp. Opening remarks by Executive Director, AERB were followed by Address by the Chief Guests and Chairman, AERB. The Board Members gave inspiring talks on their journeys and the hard work put by them while pursuing their research activities. Their lectures were quite impactful for young officers and staff of AERB Secretariat. AERB released the special logo on "Azadi Ka Amrit Mahotsav" and its Organisational Brochure for distribution among stakeholders and the public during safety promotion and outreach events.

AERB started its award scheme from the year 2012 to promote excellence among its staff and to recognise outstanding achievements of those engaged in

regulatory and associated R&D activities. AERB award scheme comprises of individual awards as well as group achievement awards.

These awards are mostly presented during AERB Formation day programme every year. However, this year due to COVID-19 pandemic, AERB has not formally awarded the staff under its award scheme. This year the awards are given against the nominations for the Awards for the year 2019.

Shri G. Nageswara Rao, Chairman, AERB addressing the Audience on 38th Formation Day Celebration

Chairman, AERB and AERB Board Members releasing AERB Brochure on 38th Formation Day Celebration

Chairman, AERB and the Board Members presented the AERB Awards for the year 2019 under various categories to the following staff of AERB.

(i) Leadership Award

Shri C.S. Varghese, ED, AERB, receiving Leadership Award-2019 from Chairman, AERB

(ii) Young Scientific/Technical Officer Award

Shri Subrata Pathak, SO/E, RSD

Shri Soumyadip Dey, SO/E, OPSD

Shri Krishna Reddy, SO/D, DRP&E

(iii) Outstanding Performance/Special Contribution Award

Smt. Manju Saini, SO/F, RSD

Dr. R. Srinivasa Rao, SO/G, NSAD

Shri Vivek Piplani, SO/G, OPSD

(iv) Meritorious Award/Group Achievement Award

Smt. Neena (Meritorious Award)

Dr. Pankaj Tandon

Shri S.C. Utkarsh

(v) Group Achievement Award

Shri Diptojyoti Bhattacharya

Smt. Uma K. Sarma

Delegates attending the Function

Glimpse of Cultural Programme during AERB Day Celebration

11.10 WELFARE AND AWARENESS ACTIVITIES FOR AERB EMPLOYEES

11.10.1 International Women's Day

International Women's Day is celebrated every year on March 8 worldwide, commemorating the political, social and economic achievements of women. The theme for the year 2021 was 'I am Generation Equality: Realizing Women's Rights'. International Women's Day was celebrated in AERB on March 8, 2021. The programme was conducted in 'hybrid' mode using physical and video-conferencing mode so that maximum AERB employees get benefitted. AERB as a progressive organization in pursuit of excellence, strives to sensitize its workforce in the areas related to gender equality, diversity and empowerment for the inclusive growth and leverage at workplace. On this occasion, an invited talk on "Gender Sensitization at Workplace - Building Gender Inclusive Culture" was delivered by Ms. Upasana A. Agarwal, Associate Professor, Organization Behaviour and Human Resource Management, NITIE, Mumbai. The main objective of the talk was to sensitize on gender equality and diversity at work place.

A cultural programme was organized by Women employees, which included dances, songs etc.

Glimpses of Women's Day Celebration at AERB

11.10.2 Celebration of National Safety Day, 2021

Every year 4th March is celebrated as National Safety Day to commemorate foundation of National Safety Council (NSC) of India in the year 1966. Theme for this year's National Safety Day-2021 was "Learn from disaster and prepare for a safer future". On the occasion of National Safety Day, a programme was organized at AERB on March 4, 2021 to honour the winners of AERB's Industrial Safety & Fire Safety Awards. Officials of AERB and various DAE units participated in the programme with restricted physical attendance and also through online platform.

Shri A. P. Garg, the then Head, OPSD, AERB gave welcome address. Executive Director, AERB in his address emphasized that everyday importance should be given to safety and it should be ensured in every action. Chairman, AERB delivered keynote address and stressed the paramount importance of safety in DAE units on occasion of National Safety Day. He emphasized that the accidents happen due to apathy. He stated that human behavioural factors such as overconfidence, negligence etc., lead to most of the occupational accidents and appealed that all officials of DAE units should strive to overcome these factors to strengthen the safety culture in their respective unit.

Chairman, AERB announced the winner DAE units of AERB Industrial Safety & Fire safety Awards for the year 2019, and also released the booklet on "Occupational Injury & Fire Statistics of the DAE units" for the year 2019.

Shri V. B. Sant, Former Director General, National Safety Council of India, delivered an invited talk on "Occupational Safety, Health & Working Conditions Code, 2020"to apprise the gathering about various significant facets of this Code. AERB officers made presentation on "Occupational Injury, Health & Fire Statistics of the DAE Units for the year 2019" and "Findings of Fatal & Serious Accidents occurred in DAE units during the year 2019-20".

Glimpses of National Safety Day Programme

Table 11.30 : Retirement on Superannuation/Resignation/Transfer

Following officials retired on superannuation, resigned/transferred to other units during the period

S.No.	Name	Designation	Date of Retirement	Remarks
1.	Shri Dinesh Kumar Shukla	Distinguished Scientist & Executive Director, AERB	28-02-2021	Retired on Superannuation
2.	Shri S. Ranganathan	Chief Administrative Officer	28-02-2021	Retired on Superannuation
3.	Dr. R.M. Nehru	Scientific Officer (G)	31-03-2021	Retired on Superannuation
4.	Smt. Lekshmi Kumari	Assistant Accountant	30-03-2021	Transferred to BARCF, Kalpakkam
5.	Shri D. K. Shinde	Deputy Controller of Accounts	30-04-2021	Retired on Superannuation
6.	Dr. K. S. Ramprasad	Scientific Officer (H)	31-05-2021	Retired on Superannuation
7.	Smt. Radha Raghavan	Senior Private Secretary	31-05-2021	Retired on Superannuation
8.	Smt. Lata Mohandas	Senior Private Secretary	30-06-2021	Retired on Superannuation
9.	Shri S. T. Swamy	Scientific Officer (H^{+}) and Head, DRP&E	31-07-2021	Retired on Superannuation
10.	Smt. Parvathi Harinarayanan	Senior Clerk	31-07-2021	Retired on Superannuation
11.	Smt. Prasanna Chandrashekhar	Senior Private Secretary	24-08-2021	Transferred to DAE, Mumbai on Promotion
12.	Dr. L.R. Bishnoi	Outstanding Scientist & Director, NSARG	31-08-2021	Retired on Superannuation
13.	Shri Hardik Setia	Upper Division Clerk	23-12-2021	Technical Resignation

CHAPTER 12

PROMOTION OF OFFICIAL LANGUAGE

CHAPTER 12 - PROMOTION OF OFFICIAL LANGUAGE

12.1 IMPLEMENTATION OF OFFICIAL LANGUAGE

AERB is committed to implementation of Official Language policy of the Government of India to create favourable environment for the use of Hindi and to motivate and encourage staff members to do their work in Hindi. It has an established programme for the implementation of official language, Hindi in various official works. In addition to the regular official works and various translations into Hindi, AERB proactively initiates a series of activities for the propagation and implementation of the official language which include: various publications, training programmes, workshops, talks, annual competitions and divisional inspections.

AERB also contributes in the activities of Joint Official Language Coordination Committee (JOLCC) comprising of DAE units viz. BRIT, HWB, DCSEM, DPS and AERB. For promotion of Hindi some of the activities conducted during the year are given below.

12.2 PUBLICATION IN HINDI

AERB Annual Report, Bulletin and Quarterly e-Newsletter has been translated and published in Hindi.

i. A press releases was issued in Hindi and published in daily newspapers.

ii. Licence, authorization and inspection reports were issued in Hindi.

iii. Total 16,632 letters were sent in bilingual (English and Hindi)

12.3 HINDI WEBINAR ON 'SAFE WORK PRACTICES AND EMERGENCY PREPAREDNESS IN INDUSTRIAL RADIOGRAPHY'

As part of AERB's sustained initiatives to promote safety awareness among its stakeholders, a webinar was organised on March 23, 2021 on 'Safe Work Practices and Emergency Preparedness in Industrial Radiography'. About 100 participants from various industrial radiography units from all over the country participated in the programme. For a wider outreach of the programme, the webinar was held in Rajbhasha Hindi.

12.3.1 World Hindi Day Celebration

World Hindi Day was celebrated on January 13, 2021. Five DAE Units viz. AERB, HWB, DCSEM, DPS and BRIT participated in the Joint Hindi Day Celebration. The function was organized by DCSEM through virtual mode. Shri Samson Varghese, CAO, HWB and Chairman, Joint Official Language Implementation Committee (OLIC) welcomed the participants.

Shri G. Nageswara Rao, Chairman, AERB addressed the function and highlighted the increasing importance of Hindi as Official Language of the Central Government, as a Link language and as World language. He also stressed that all the Government officers and staff should strive towards encouraging use of Hindi in daily use by providing better environment in the office to the employees.

Participants of Hindi Workshop held at AERB

12.3.2 Joint Hindi Workshops

On 25th and 26th August 2021 in BRIT, 21st and 22nd October 2021 in Convention Centre, Anushakti Nagar, on 1st and 2nd December 2021 two-day joint Hindi workshops were organized, in which 3 officers and 6 employees of AERB participated. Lectures were delivered by the Assistant Director (OL) of AERB in these workshops.

12.3.3 Celebration of Hindi Day

Hindi Day was celebrated on September 14, 2021. Heavy Water Board, Mumbai organised the function through Videoconferencing on behalf of Joint Official Language Coordination Committee (JOLCC) comprising of AERB and DAE units viz. BRIT, Heavy Water Board (HWB), DCSEM and DPS.

Shri G. Nageswara Rao, Chairman, AERB addressed the gathering highlighting the increasing importance of Hindi as Official Language of the Central Government.

Following activities were performed to promote Hindi language:

a) Hindi essay writing competitions were organized for officers and employees in AERB in September 2021 in which total 15 officials participated.

b) On August 25, 2021, joint Hindi competitions were organized by JOLCC, which included interesting event writing competition, self-written poetry competition, story competition, Hindi essay competition, in which 06 participants of AERB were winners.

c) On August 25 and 26, 2021, a joint Hindi workshop was organized in BRIT, in which two officers and one employee of AERB participated. A lecture was delivered by Assistant Director (OL), AERB in this workshop.

d) AERB Officer delivered a lecture in Hindi in the Awareness Programme organized by Institute of Physics (IOP), Bhubaneswar on a topic "Safe Work Practices and Emergency Preparedness in Industrial Radiography". Assistant Director (OL), AERB also participated in this workshop.

12.4 RANGOLI-CUM-HINDI-CAPTION-HINDI SPEECH COMPETITION

"Rangoli-cum-Hindi-Caption-Hindi Speech Competition" was organized in AERB on 13th August 2021 on the occasion of 'Azadi Ka Amrit Mahotsav' in which total 17 officers and employees participated.

Glimpses of various competitions conducted during 'Azadi Ka Amrit Mahotsav'

A joint "Virtual Hindi Day Celebration" was organized on 14th September 2021. Chairman, AERB addressed the audience for the on-line "Virtual Hindi Divas Celebrations".

12.4.1 Essay Writing Competition

Hindi essay writing competition was organized for officers and employees in AERB in September 2021 in which total 15 officers and employees of AERB participated.

12.5 AZADI KA AMRIT MAHOTSAV

'Azadi Ka Amrit Mahotsav' is a series of activities being organised to celebrate and commemorate the 75th anniversary of India's independence, 75 years of progressive India and the glorious history of its people, culture and achievements. Azadi ka Amrit Mahotsav embodies all that is progressive about India's socio-cultural, political and economic identity. Over the last four decades, AERB has evolved into an organisation of international repute with state of the art knowledge robust regulatory infrastructure and has been effectively and efficiently serving the nation in nuclear and radiation safety regulation. This journey is marked by numerous significant milestones and filled with many proud moments. To commemorate AERB's contribution to nation-building, AERB plans to join the national celebrations 'Azadi ka Amrit Mahotsav' in a befitting manner for the entire year.

AERB organised a "live quiz competition" in Hindi on 22nd September 2021 on the occasion of Azadi Ka Amrit Mahotsav. In this competition, questions related to the freedom struggle and the Constitution of India were asked. The participants who gave correct answers were given prizes on the spot by Shri K. Venkata Subramanian, CAO, AERB and Shri Krishnakumar V., AO-III, AERB. Shri Vaibhav Gholap, Scientific Officer/E, AERB, served as the Quiz Master. Shri Dhanesh Parmar, Assistant Director (OL), conducted the program. To commemorate AERB's contribution in nation-building, AERB has planned to join the national celebrations' Azadi Ka Amrit Mahotsav' in a befitting manner for the entire year. Several events such as seminars/webinars/colloquia, engaging with the public, schools and academic institutions, organising quizzes and competitions, safety promotional events, awareness programmes, media outreach etc were organized during the year.

During the period following activities were organized in AERB.

a) A live quiz competition in Hindi was organized on September 22, 2021 at AERB, covering topics related to freedom struggle and Constitution of India. Shri Vaibhav Gholap, Scientific Officer/E, AERB served as the Quiz Master. The program was conducted by Shri Dhanesh Parmar, Assistant Director (OL).



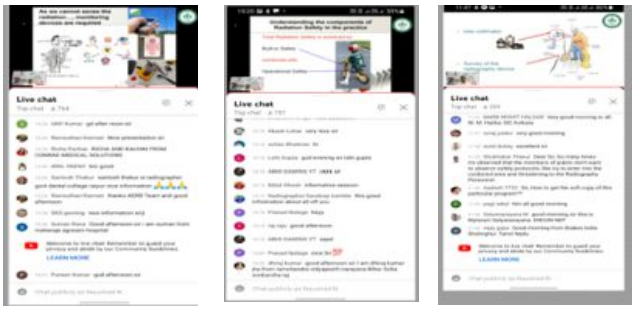

Glimpses of various Programmes conducted during 'Azadi Ka Amrit Mahotsav'


Glimpse of IR Hindi


Glimpse of DR Hindi


Glimpse of IR Malayalam

Glimpse of DR Oriya



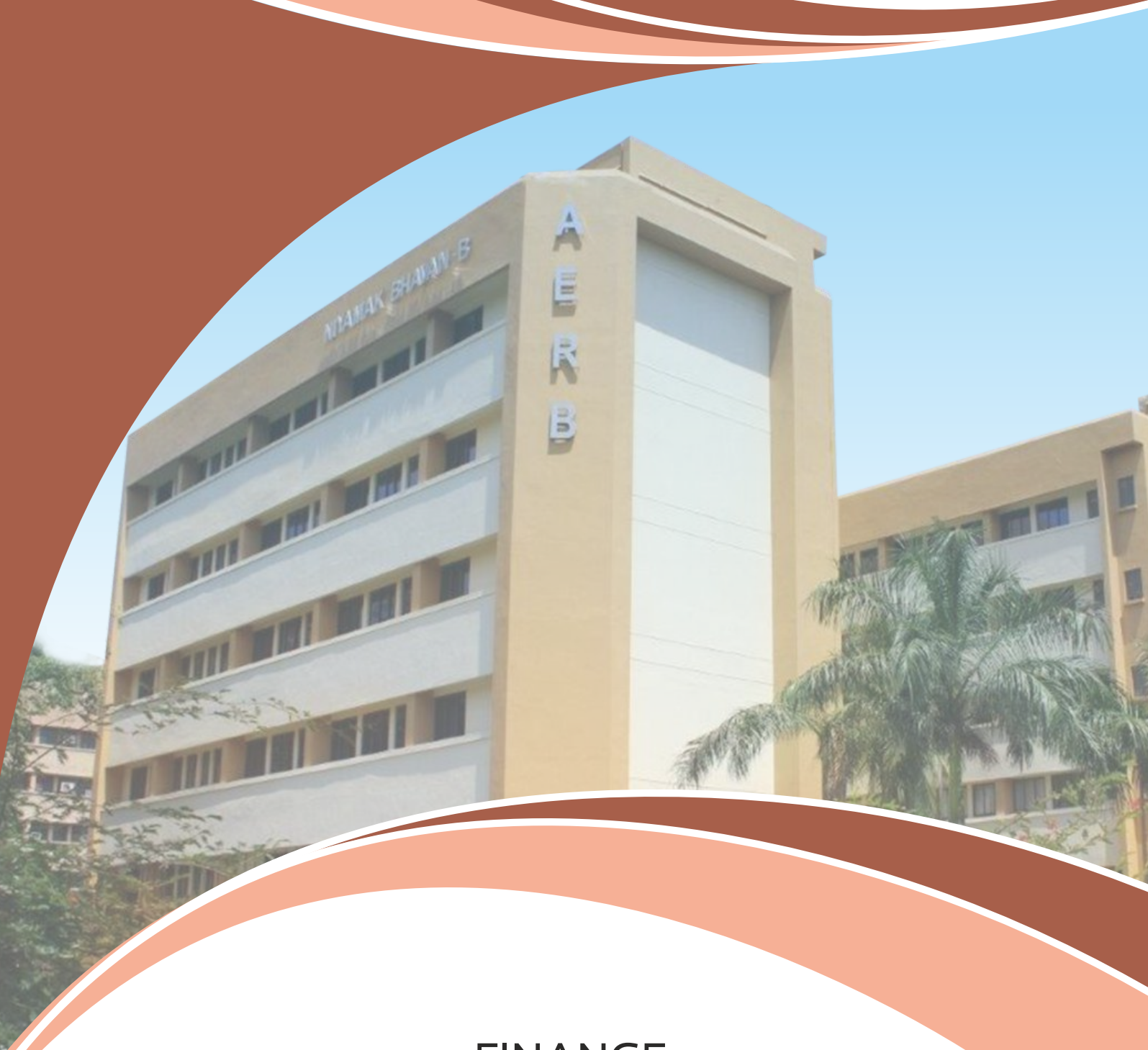
Glimpses of Live-streaming Feedback/Live Chat during Awareness Programmes

Celebration of 75th Independence Day

Shri G. Nageswara Rao, Chairman, AERB hoisted the National Tri-colour at AERB premises on August 15, 2021. 'Azadi Ka Amrit Mahotsav' is being celebrated to commemorate the 75th year of independence.

Glimpses of Celebration of 75th Independence Day at AERB

CHAPTER 13



FINANCE

CHAPTER 13 - FINANCE

AERB receives funds from the Government of India (GoI) for meeting its expenditure. AERB has full powers to operate its budget, which it prepares and submits for approval.

13.1 ANNUAL BUDGET OF AERB AND ITS UTILISATION

Annual expenditure during the period was Rs. 91.06 crores comprising Rs. 25.97 crores under Capital Budget, Rs. 64.32 crores under Revenue Budget and Rs. 0.77 crores towards Grant-in-Aid Scheme. Expenditure includes Salary, Office expenses, travel, public outreach programme, services of experts, Grant-in-aid towards financial assistance for projects of AERB interest to academic institutes and grants for seminars/conferences.

Expenditure for Capital is mainly towards construction of Niyamak Bhavan - C at HQ, salary of new recruits under continued project, establishment of Regional Regulatory Centre (RRC), R&D activities and IT related activities.

Online Payments through Public Financial Management System (PFMS) programme have been successfully made during the year 2021 towards Contractors bills, Electricity bills, Telephone bills, Honorarium of Consultants/Specialists and Retirement Gratuity, Commutation Pension, Leave encashment, Provident Fund etc. in respect of retired employees of AERB.

13.2 RESEARCH AND DEVELOPMENT AND IT INFRASTRUCTURE

Funds were utilised for procurement of software for analysis work at AERB HQ and at SRI Kalpakkam and establishing experimental facilities at SRI for R&D activities.

Funds were also utilised to improve internal IT infrastructure like procurement and implementation of On-premise software based video conferencing system (TrueConf) to enable conduct of virtual meetings during COVID-19 pandemic. Implementation of continuous upgradation/improvement plan for e-LORA covering important regulatory activities and enhancing Virtual Private Network (VPN) connections to enable timely processing of applications in e-LORA during tele-work.

13.3 GRANTS TO RESEARCH PROJECTS

AERB provides grants to academic institutions for research projects to carry out safety research in the areas of AERB's interest. Details of CSRP projects are provided in section 7.10 of this report. The research outcome is used for framing new regulations, safety review and analysis etc.

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(ii) C. Anandan and C. Senthil Kumar, "Investigation of Changes in Beach Morphology due to Coastal Armoring", Energy and Environment Research; Vol. 11, No. 1; May, 2021.

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(iv) A. Arunasis Bhattachatyya, Avinash S. Kanekar, N.S.Karthikeyan, C.Ravichandran, B.Venkatachalapathy, T.Subba Rao, H.Seshadri and Prasanta K.Mohapatra, "Aqueous soluble 'N' do not heterocyclic ligands for the mutual separation of Am^{3+} and Eu^{3+}: Solvent extraction, flat sheet supported liquid membrane and hollow fibre micro extraction studies", Journal of Environmental Chemical Engineering 9(2021)106041.

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(viii) P. Ramakrishna, Sitakanta Panda, P Vinod Kumar, R. K. Padhi, Hrudananda Jena and B S Panigrahi, "Structural and Spectroscopic Investigations of Neodymium doped Strontium Borophosphate glasses Luminescence", Volume 36, Issue 7, November 2021 Pages 1706-1715 https://doi.org/10.1002/bio.4112

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(v) P. Ramakrishna, S.K. Panda, P. Vinod Kumar, H.N. Jena and B.S. Panigrahi, "Structural and optical properties of gadolinium and europium co-doped strontium borophosphate glasses"; National Webinar cum Workshop on Luminescence Applications and Materials (NWWLAM-21), 25-Jun-2021.

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ABBREVIATIONS

ACNRS	Advisory Committee on Nuclear and Radiation Safety
ACOH	Advisory Committee on Occupational Health
ACPSR	Advisory Committee for Project Safety Review
ACS	Advisory Committee on Security
AER	Atomic Energy Research
AE (RP)	Atomic Energy Radiation Protection
AERB	Atomic Energy Regulatory Board
AFR	Away From Reactor
AAFR	Additional Away From Reactor
AGFS	AERB Graduate Fellowship Scheme
AGMS	Annulus Gas Monitoring System
AGM	Accident Management Guidelines
AIIMS	All India Institute of Medical Sciences
ALARA	As Low as Reasonably Achievable
AMD	Atomic Minerals Directorate for Exploration and Research
AMG	Accident Management Guideline
APAR	Annual Performance Appraisal Report
ARPF	Agricultural and Radiation Processing Facility
ASCE	Assistant Shift Charge Engineer
ASME	American Society of Mechanical Engineers
ATI	Administrative Training Institute
AOT	Allowed Outage Time
ASTET	AERB Source Term Estimation Tool
ASTM	American Society for Testing and Materials
BARC	Bhabha Atomic Research Centre
BDBE	Beyond Design Basis Event
BHAVINI	Bharatiya Nabhikiya Vidyut Nigam Limited
BITS	Birla Institute of Technology and Science
BDL	Below Detection Limit
BWR	Boiling Water Reactor
BOC	Bureau of Outreach & Communication
BRIT	Board of Radiation & Isotope Technology
BSD	Biennial Shutdown
BSM	Beach Sand Minerals
CANDU	Canada Deuterium Uranium
CBS	Computer based systems
CCC	Construction Completion Certificate
CCP	Critical Channel Power
CISF	Central Industrial Security Force
CIWH	Condensation Induced Water Hammer
CDA	Core Disruptive Accident
CSIR	Council of Scientific & Industrial Research
CSTS	Calandria Side Tube Sheet
CTMS	Channel outlet temperature system
CWMF	Centralised Waste Management Facilities
CE	Control Engineer
CESC	Civil Engineering Safety Committee
CFD	Computational Fluid Dynamics
CFTF	Compartment Fire Test Facility
CFVS	Containment Filtered Venting System
CHARMS	Corporate Human Assets and Resources Management System
CHF	Critical Heat Flux
CHFR	Critical Heat Flux Ratios
CMG	Crisis Management Group
CNS	Convention on Nuclear Safety
CNRA	Committee of Nuclear Regulatory Activities

C&I	Control & Instrumentation
CNSC	Nuclear Regulatory Body of Canada
CR	Commissioning Reports
CSL	Cross Hole Sonic Logging
CSR	Corporate Social Responsibility
CV	Control Valve
COMREF	Core Melt Retention Facility
COSTRAM	Committee for Safe Transport of Radioactive Material
CORAL	Compact Reprocessing of Advanced Fuels in Lead Cell
CPGRAMS	Centralized Public Grievance Redress and Monitoring system
CPRF	Combined Piled Raft Foundation
CPSAR	Control and Protection System Absorber Rods
CPWG	ANDU PSA Working Group
CRP	Coordinated Research Project
CRSA	Committee for Reviewing Security Aspects
CSP	Core Sub-Assembly Plant
CSRP	Committee for Safety Research Programmes
CSS	Commission on Safety Standards/ Containment Spray System
CT	Calandria Tubes/Computed Tomography
CWMF	Centralised Waste Management Facility
DAE	Department of Atomic Energy
DAE-SCSR	DAE Steering Committee to Coordinate Safety Research
DAVP	Directorate of Advertising and Visual Publicity
DBR	Design Basis Report
DBGM	Design Basis Ground Motion
DCC	Direct Contact Condensation
DCSEM	Directorate of Construction, Services & Estate Management
DDMP	District Disaster Management Plan
DEC	Design Extension Condition
DFMF	Demonstration Facility for Metallic Fuel Fabrication
DFRP	Demonstration Fast Reactor Fuel Reprocessing Plant
DGHS	Directorate General of Health Services
DGFT	Director General of Foreign Trades
DMZ	Demilitarized Zone
DPP	Document Preparation Profile
DPS	Directorate of Purchase and Stores
DRA&C	Directorate of Regulatory Affairs and Communications
DRI	Directorate of Regulatory Inspection
DRP&E	Directorate of Radiation Protection and Environment
DRS	Directorate of Radiation Safety
DSHA	Deterministic Seismic Hazard Analysis
DSRS	Disused Sealed Radioactive Sources
DSS	Decision Support System
EAL	Emergency Action Level
ECCS	Emergency Core Cooling System
ECIL	Electronics Corporation of India Limited
EDRMA	Electronic Documents and Record Management System
EFPD	Effective Full Power Day
EDX	Energy Dispersive X-ray
e-LORA	Electronic Licensing of Radiation Applications
EMCCR	En-Masse Coolant Channel Replacement
EOC	Emergency Operation Centre
EPR	Evolutionary Pressurised Reactor
EPR	Emergency Preparedness & Response
EQ	Equipment/ Environmental Qualification

ER	Event Reports
ERRC	Eastern Regional Regulatory Centre
ERSD	Emerging Regulatory Strategy Division
ESL	Environmental Survey Laboratories
FAC	First Approach to Criticality
FAS	Fuel Sub-Assemblies
FB	Fuel Building
FBR	Fast Breeder Reactor
FBTR	Fast Breeder Test Reactor
FCF	Fuel Cycle Facilities
FFP	Fuel Fabrication Plant
FINAS	Fuel Incident Notification and Analysis System
FMS	Flux Mapping System
FOAK	First-of-A-Kind
FP	Fission Products
FPC	First Pour of Concrete
FPNG	Fission Product Noble Gases
FR	Frequency Rate
FRFCF	Fast Reactor Fuel Cycle Facility
GAEC	Ghana Atomic Energy Commission
GCNEP	Global Centre for Nuclear Energy Partnership
GHAVP	Gorakhpur Haryana Anu Vidyut Pariyojana
GIC	Gamma Irradiation Chamber
GIS	Geographic Information System
GRAPF	Gamma Radiation Processing Facilities
GSR	General Safety Requirements
GUI	Graphical User Interface
HBNI	Homi Bhabha National Institute
HLLW	High-Level Liquid Waste
HS&EG	Health, Safety and Environment Group
HWP	Heavy Water Plant
HYMIF	Hydrogen Mitigation Facility
HQ	Head Quarter
I&C	Instrumentation & Control
IAEA	International Atomic Energy Agency
IARPF	Industrial Accelerator Radiation Processing Facility
IC	Inner Containment
ICTP	International Centre for Theoretical Physics
ICCR	Integrated Command Control and Response
ICRP	International Commission on Radiological Protection
IFBA	Integral Fuel Burnable Absorber
IFL	Initial Fuel Loading
IFSB	Interim Fuel Storage Building
IGALL	International Generic Ageing Lessons Learned
IGCAR	Indira Gandhi Centre for Atomic Research
IGRED	Industrial Gamma Radiation Exposure Device
IGSCC	Inter Granular Stress Corrosion Cracking
IHRG	In-house Review Group
II	Injury Index
IIP	Indian Institute of Packaging
IIT	Indian Institute of Technology
ILRT	Integrated Leak Rate Test
IMS	Integrated Management System
INES	International Nuclear and Radiological Event Scale
IPHWR	Indian PHWR
I&CT	Information and Communication Technology
I&FS	Industrial and Fire Safety
IPPF	Isotope Production and Processing Facility
IR	Industrial Radiography
IRRS	Integrated Regulatory Review Service

IRS	Incident Reporting System
IRGD	Radiation Gauging Devices
IRED	Radiography Exposure Device
ISI	In-service Inspection
ISO	International Organisation for Standardisation
IT	Information Technology
ITI	Industrial Training Institute
JHA	Job Hazard Analysis
KAPS	Kakrapar Atomic Power Station
KAPP	Kakrapar Atomic Power Project
KGS	Kaiga Nuclear Power Station
KAMINI	Kalpakkam Mini Reactor
KKNPP	Kudankulam Nuclear Power Project
KRSC	KGS-1 to 4 and RAPS-3 to 6 Safety Committee
LB	Land Breeze
LECCS	Loss of ECCS
LMODC	Loss of Moderator Cooling
LOCA	Loss of Coolant Accident
LOFA	Loss of Flow Accident
LRP	Large Rotatable Plug
LPSD PSA	Low Power and Shut down PSA
LTO	Long Term Operation
L&SC	Legal & Security Cell
LWC	Light Water Commissioning
LWR	Light Water Reactor
LZCS	Loss of Zonal Control System
MAPS	Madras Atomic Power Station
MDEP	Multi-National Design Evaluation Programme
MDP	Management Development Programme
MEE	Major Equipment Erection
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoHFW	Ministry of Health and Family Welfare
MoEF	Ministry of Environment and Forests
MoPP	Monazite Processing Plant
MORTH	Ministry of Road Transport and Highways
MoU	Memorandum of Understanding
MSBR	Molten Salt Breeder Reactor
MW	Mega Watt
NDT	Non-destructive Testing
NF	Nuclear Facility
NHA	National Health Authority
NG	Nucleonic Gauges
NODRS	National Occupational Dose Registry System
NRB	Nuclear Recycle Board
NRRC	Northern Regional Regulatory Centre
NUOFP	New Uranium Oxide Fuel Plant
N&IF	Nuclear & Industrial Facilities
NAARRI	National Association for Applications of Radioisotopes and Radiation in Industry
NABL	National Accreditation Board for Testing and Calibration Laboratories
NAPS	Narora Atomic Power Station
NB	Nucleate Building
NC	Non Conformance
NCRI	National Conference on Regulatory Interface
NDHM	National Digital Health Mission
NDMA	National Disaster Management Authority
NEA	Nuclear Energy Agency
NEMIS	Nuclear Emergency Management Information System
NFC	Nuclear Fuel Complex
NFRG	Nuclear Facilities Regulation Group
NHA	National Health Authority
NHRC	National Human Rights Commission
NIC	National Informatics Centre

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
NREMC	Nuclear and Radiological Emergency Monitoring Cell
NSAD	Nuclear Safety Analysis Division
NSARG	Nuclear Safety Analysis and Research Group
NUREG	US Nuclear Regulatory Commission Regulation
OECD	Organisation for Economic Cooperation and Development
OESC	On-Site Emergency Support Centre
OEM	Origin Equipment Manufacturer
OHSC	Occupational Health Safety Committee
OLIC	Official Language Implementation Committee
OPRD	Over Pressure Rupture Device
OPSD	Operating Plants Safety Division
OSCOM	Odisha Sand Complex
OSEE	Off-site Emergency Exercise
OSL	Optically Stimulated Luminescence
PAHMS	Post-Accident Hydrogen Management System
PARF	Particle Accelerator Research Facilities
PC	Primary Containment
PCCS	Passive Containment Cooling System
PCR	Passive Catalytic Re-combiners
PCRD	Passive Catalytic Recombiner Devices
PDHRS	Passive Decay Heat Removal System
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
PIE	Post Irradiation Examination
PSA	Probabilistic Safety Assessment
PSAI	Pre-Shipment Inspection Agencies
PSAR	Preliminary Safety Analysis Report
PSHA	Probabilistic Seismic Hazard Analysis
PSR	Periodic Safety Review
PT	Pressure Tube
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
RCF	Rashtriya Chemicals and Fertilisers
RCS	Reactor Containment System
REGDOC	Regulatory Safety Documents
RERD	Radiation Emergency Response Director
RF	Radio Frequency
RI	Regulatory Inspection
RIA	Radiological Impact Assessment
RIMP	Records and Information Management Policy
RMC	Radiation Medicine Centre
RAPCOFF	RAPP Cobalt Facility
ROPP	Regional Over-power Protection
ROPS	Regional Overpower Protection Systems
RR	Rawatbhata Rajasthan
RPF	Radiation Processing Facility
RRC	Regional Regulatory Centres

RRCAT	Raja Ramanna Centre for Advanced Technology
RRS	Reactor regulating System
RSA	Radiation Safety Agency
RSD	Radiological Safety Division/ Refuelling Shutdown
RSNSA	Radiation Safety and Nuclear Security Authority
RSO	Radiological Safety Officer
RTD	Resistance Temperature Detector
RCCA	Rod Cluster Control Assembly
RCL	Radio Chemistry Laboratory
RPR	Radioisotope Production Reactor
RR	Research Reactor
RRI	Remote Regulatory Inspection
RTI	Right to Information
RUP	Reprocessed Uranium Plant
SA	Severe Accident
SAAP	Severe Accident Analysis Programme
SAMG	Severe Accident Analysis & Management Guidelines
SAR	Safety Analysis Report
SARCAR	Safety Review Committee for Applications of Radiation
SARCOP	Safety Review Committee for Operating Plants
SC	Safety Code
SCCI&CS	Standing Committee on Control for Instrumentation & Computer Based Systems
SCE	Shift Charge Engineer
SC-RP	Standing Committee Reactor Physics
SCRD	Standing Committee on REGDOCs
SCRAM	Safety and Control Rod Accelerated Movement
SDDP	Safety Document Development Proposal
SEC	Site Evaluation Committee
SEE	Site Emergency Exercise
SEM	Scanning Electron Microscope
SER	Significant Event Report
SER	Site Evaluation Report
SFCT	Sodium Facility for Component Testing
SG	Safety Guide/Steam Generator
SIT	Structural Integrity Test
STP	Sewage Treatment Plants
SPND	Self Powered Neutron Detector
SRPH	Safety Related Pump House
SM	Safety Manual
SOP	Standard Operating Procedure
SOT	Site Observer Team
SPECT	Single Photon Emission Computed Tomography
SR	Severity Rate
SRI	Safety Research Institute
SRRC	Southern Regional Regulatory Centre
SRP	Small Rotatable Plug
SS	Safety Standard
SSC	Structures, Systems and Components
SSI	Soil Structure Interaction
SSMC	Secondary Sodium Main Circuits
SSR	Safety Status Report
TAPS	Tarapur Atomic Power Station
TB	Turbine Building
TBP	Tri Butyl Phosphate
TDP	Technology Demonstration Plant
TECDOC	Technical Document
TF	Task Force
TG	Turbine Generator
TMH	Tata Memorial Hospital
TT	Table-Top
TSL	Thermally Stimulated Luminescence

TSO	Technical Support Organisation
TISS	Tata Institute of Social Sciences
TLD	Thermo Luminescence Dosimetry
TM	Technical Meeting
TMH	Tata Memorial Hospital
TOPA	Transient Over Power Accident
TPA	Tons Per Annum
UCIL	Uranium Corporation of India Limited
UNDP	United Nations Development Programme
USNRC	United States Nuclear Regulatory Commission
UT	Ultrasound Testing
VECC	Variable Energy Cyclotron Centre
VPN	Virtual Private Network
VSPP	Versatile Solvent Production Plant
VVER	Vodo-Vodyanoi Energetichesky Reactor
WASIF	Water and Steam Interaction Facility
WG	Working Group
WL	Well Logging
WMP	Waste Management Plant
WRF	Waste Recycle Facility
XIC	X-ray Irradiation Chamber
XRD	X-ray Diffraction
YASHADA	Yashwantrao Chavan Academy of Development Administration
ZC	Zirconium Complex
ZFF	Zircaloy Fabrication Facility

INTERNATIONAL NUCLEAR AND RADIOLOGICAL EVENT SCALE (INES)

Level/Descriptor	Name of the Events	Examples
7 MAJOR ACCIDENT	Major release: Widespread health and environmental effects requiring implementation of planned and extended countermeasures.	Chernobyl NPP, USSR (now in Ukraine), 1986 Fukushima NPPs, Japan, 2011
6 SERIOUS ACCIDENT	Significant release: Likely to require full implementation of planned countermeasures.	Kyshtym Reprocessing Plant Russia, 1957
5 ACCIDENT WITH WIDER CONSEQUENCES	• Limited release: Likely to require full implementation of planned countermeasures. • Severe damage to reactor core/several deaths from radiation. • 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.	Windscale Pile UK, 1957 Three Mile Island, NPP, USA, 1979 Goiania, Brazil, 1987
4 ACCIDENT WITH LOCAL CONSEQUENCES	• Minor release of radioactive material unlikely to result in implementation of planned countermeasures other than local food controls. • Fuels melt or damage to fuel resulting in more than 0.1% release of core inventory. • At least one death from radiation/Release of significant quantities of radioactive material within an installation with a high probability of significant public exposure.	Tokaimuro, Japan, 1999 Saint-Laurent des Eaux NPP, France, 1980 Fleurus, Belgium, 2006 Mayapuri Incident, New Delhi, India, 2010
3 SERIOUS INCIDENT	• Near-accident of an NPP with no safety provisions remaining. • Highly radioactive sealed source lost or stolen/ misdelivered without adequate radiation procedures in place to handle it. • Exposure rates of more than 1 Sv/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.	Vandelous NPP, Spain, 1989 Ikiteli, Turkey, 1999 Sellafield, UK, 2005 Yanango, Peru, 1999
2 INCIDENT	• 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 material sealed source.	Forsmark, Sweden, 2006 Atucha, Argentina, 2005
1 FACILITY/THEFT OF RADIOACTIVE SOURCE	• Minor problems with safety components with significant defence-in-depth remaining low activity lost or stolen radioactive source, Device or transport package. • Overexposure of a member of the public in excess of statutory annual limits.	Breach of operating limits at a nuclear facility/theft radioactive source
0 DEVIATION BELOW SCALE	• No safety significance	

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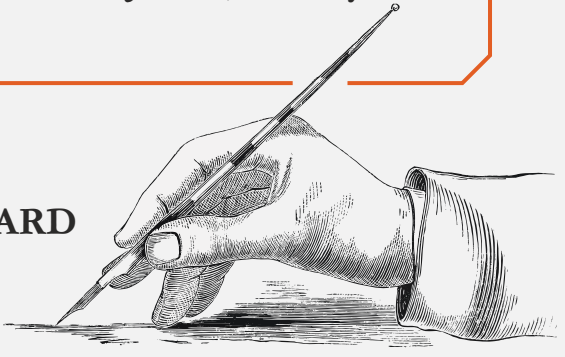

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