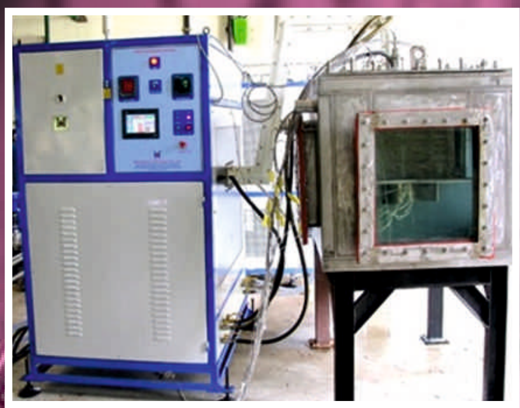
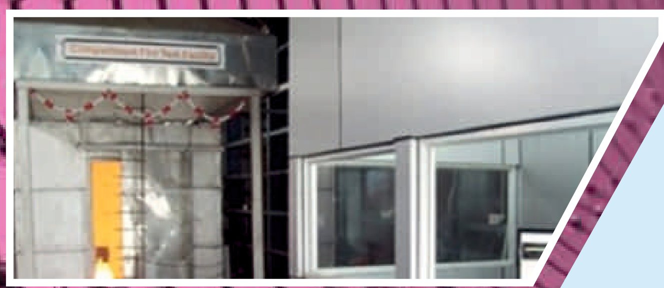
Indian Nuclear Society

INS Newsletter





Indian Nuclear Society's Annual Conference

INSAC-2024

Regulatory Framework for Nuclear Renaissance

November 19-21, 2024

Web. : www.insac2024.org | Email : insac2024@gmail.com

July - December 2024

Special Issue - 3 & 4

Vol. 25

CONTENTS

Editor's Desk

Dear INS fellow members,

Very warm regards and greetings. INS newsletter has been a rich source of scientific and technical information wherein important events, developments, breakthrough accomplished by scientists and engineers of DAE are regularly published. In addition, reports on several outreach programs undertaken by INS for schools, colleges and institutions are regularly published in the newsletter. For this the editorial team puts lot of efforts for contacting and discussing with individuals in different units of the department to get to know the information and articles worth sharing with members.

Even though in the last six months INS was engaged in many activities, this special issue has been brought out on regulatory activities of AERB. In fact when it became due to organise annual conference this year, the executive committee decided to approach AERB with a proposal to jointly organise the conference. In spite of being heavily engaged in safety clearance for important projects of the department, AERB readily agreed with the proposal. In tune with the current thrust for building more advanced nuclear reactors, the title of the conference was decided as "Regulatory Framework for Nuclear Renaissance". Nuclear renaissance is a global fact and regulatory framework that can address the issue of advances in nuclear design becomes even more important and critical. Very soon the industry will demand clean energy to meet the carbon footprint tag to be relevant in the global market. The industries that work on base load source of power need support of clean energy base load power. Today nuclear happens to be the only alternative. With newer design of nuclear reactor the challenges of safety regulation will need newer codes supported by R&D to enable AERB to issue early licences.

The conference is being organised in DAE Convention Centre from 19-21 November 2024. The technical session in the conference has invited talks and panel discussion by experts on regulatory framework. The conference will also have poster session on technical papers on safety review, research, development, technology and validation of advance features.

This special newsletter has seven special articles by AERB and one article about INS lecture given under INS-Young Nuclear Professional forum.

The first article is on "AERB's regulatory safety documents" specifying requirements and providing guidance and are issued in the form of Regulatory Documents (REGDOCs) in accordance with the legal system and regulatory framework using the provisions of Atomic Energy (Radiation Protection) Rules, 2004. These are used for core regulatory processes such as review and assessment, as a part of licensing process, in carrying out regulatory inspections, and when determining the enforcement actions. AERB has taken certain initiative in recent times to ensure continued applicability and updating of its

REGDOCs so that the requirements and guidance remains robust to potential changes in nuclear programme in near future.

The next article is on 'Licensing and Regulatory Oversight of Nuclear Power Plants in India'. Safety is of paramount importance in the siting, design, construction, commissioning and operation of nuclear power plants. The overarching objective is to implement measures with the objectives of preventing accidents and mitigate their potential consequences, should they occur. This approach includes practically eliminating the accident scenarios that could lead to unacceptable radiological consequences. The article also gives an overview of AERB regulatory structure, its regulatory processes and future challenges.

The article on "Regulations in Radiation Applications and its Strengthening post Mayapuri Accident", the Mayapuri accident which stands as a stark reminder to the need for continuous vigilance, knowledge dissemination and diligence in preserving public safety and averting potential disasters has been brought out. Post Mayapuri accident, AERB has taken a comprehensive re-evaluation and initiated steps to further strengthening the radiation safety aspects. Nevertheless, the primary responsibility for ensuring safety and security of radiation sources rests with the licensee of the radiation facility.

The article on "AERB activities towards enhancement of public trust and stakeholders' engagement" deals with building public trust. It is about stakeholder engagement identified as one of the nineteen infrastructure issues covered in the IAEA's milestone approach, a structured methodology used by the member states for development of infrastructure for a new or expanding nuclear power programme. The article addresses about communication strategy of AERB, about National Conference on Regulatory Interface (NCRI) started in the year 2017. The objective is to foster an environment wherein professional associations could interact, discuss and provide valuable feedback to AERB on various issues related to Nuclear / Radiation Safety, regulatory requirements and practices world-wide, emerging trends in design and manufacturing, challenges in supply chain and other issues of regulatory interest. Through such programs, AERB is contemplating to explore emergent technologies, social media for maximizing the effectiveness of its communication and outreach programmes.

The article on "IAEA review of the regulatory infrastructure of India for nuclear and radiation safety" is about engaging IAEA. At the request of the Government of India, IAEA organized an Integrated Regulatory Review Service (IRRS) Extended Follow up Mission as part of the 1st IRRS India cycle. The IRRS team have identified three recommendations and three suggestions in their final assessment. Some of these recommendations / suggestions are related to formalizing the practices into formal written down procedures and to strengthen internal management processes. AERB has accepted these as an opportunity to further improve the regulatory framework.

Article on 'Changes in the Framework of Emergency Preparedness and Response after the Fukushima Accident' elaborates significant progress made in strengthening Emergency Preparedness and Response framework in India. This is achieved through changes in key areas encompassing revision of regulatory requirements, restructuring of response framework along with clear roles and responsibilities, development and deployment of decision support system, among others. A comprehensive off-site emergency exercise program is instituted by introducing modular and integrated type of exercises.

In another article, "Role of Safety Research at AERB for Nuclear Regulation" research in safety has been the focus. The article is about the R&D activities carried out in AERB's Safety Research Institute (SRI) in Kalpakkam. It highlights contributions in wide range of nuclear safety related topics that include but not limited to reactor and radiation physics, reactor thermal hydraulics and safety, nuclear chemistry and environmental impact assessment. These research topics have a bearing on the protection of public and environment from undue risks of radiation. The independent safety research programme established by AERB has strengthened the regulatory review and decision-making process based on credible information and technically sound judgment.

The last article pertains to AERB activities and gives a summary report on the lecture organised by INS on "Nuclear fuel cycle and advanced fuel" under INS-Young Nuclear Professional forum. About 40 engineers from various units of DAE and AERB attended the lecture. INS Vice-President Shri Satyawan Bansal and Treasurer, Shri O.P. Rai welcomed the expert speaker and the participants. The intention of the talk was to create awareness among young engineers of the department about latest updates on advanced fuels.

Members are requested to go through the articles and send their positive and critical remarks to add more value to the functioning and approach of safety culture in our plants. INS thanks all authors for their valuable contributions to this very special issue. We sincerely hope that the readers will appreciate the involvement and commitment of AERB in ensuring unshaken safety in our operating plants and facilities.

- Dr. A Rama Rao

AERB'S REGULATOY SAFETY DOCUMENTS

Parikshat Bansal, Dr. R. B Solanki, Rajoo Kumar & Bijendra Kumar
Resources & Documentation Division
Atomic Energy Regulatory Board

Atomic Energy Regulatory Board (AERB) was constituted in 1983, to carry out certain regulatory and safety functions envisaged under Section16, 17 and 23 of the Atomic Energy Act, 1962. AERB develops and lays down regulatory safety requirements and guidance for the entire spectrum of nuclear and radiation facilities and activities, under its purview, applying graded approach. These are issued in the form of Regulatory Documents (REGDOCs) in accordance with the legal system, and regulatory framework using the provisions of Atomic Energy (Radiation Protection) Rules, 2004. AERB has also developed regulations and guidance on security aspects having bearing on the safety, in accordance with its mandate.

With a view to ensuring the protection of occupational workers, members of public and the environment from harmful effects of ionizing radiation, the AERB REGDOCs specifies safety requirements and guidance at all stages of lifetime of nuclear & radiation facilities and associated activities. These requirements and guidance are developed such that the radiation exposure of members of public, occupational workers and the release of radioactive material to the environment are controlled and optimized, the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation is limited, and the consequences of such events if they were to occur are mitigated to the extent practicable. The requirements and guidance contained in these REGDOCs are used for core regulatory processes such as review and assessment, as a part of licensing process, in carrying out regulatory inspections, and when determining the enforcement actions.

The principal users of AERB regulatory documents are applicants, licensees, and other associate persons in nuclear and radiation facilities including members of the public. AERB REGDOCs are applicable, as relevant, throughout the entire lifetime of radiation and nuclear facilities and associated activities.

STRATEGIC DIRECTIONS AND GUIDANCE

AERB has developed the strategic directions and guidance which are necessary for establishing and maintaining up to date regulations and guidance, as part of its process. The broad strategic directions for regulations and guidance are:

a) To be in accordance with the legal system, and regulatory framework

b) To make, regulations and guidance which are technology and entity neutral.

c) To serve as means to ensure that regulatory control is stable and consistent.

d) To be unambiguous and consistent so that the subjective interpretations are minimized.

e) To provide bases for decision making by AERB.

f) To refrain from prescribing specific solutions, specific design options, and provisions in management systems or operational procedures.

g) To adopt a balanced approach between prescriptive, performance based and process based regulation.

h) To apply graded approach taking into account of hazard potential commensurate with the radiation risks associated with the type of facility or activity and associated complexities.

i) To be periodically reviewed and updated.

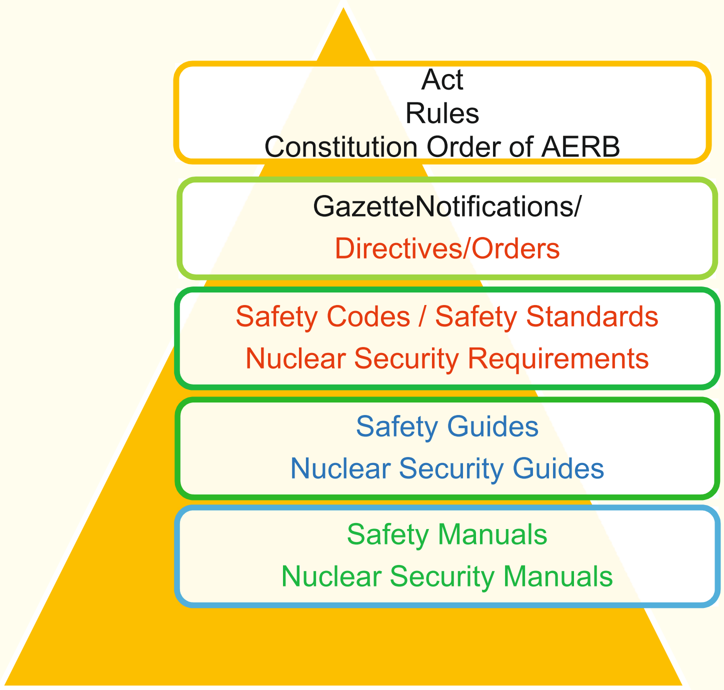
j) To provide performance criteria for structures, systems and components, and management and operational procedures and processes, to be achieved during siting, design, construction, operation and decommissioning of facilities.

k) To use the 'Harmonized' definitions of terms, as given in AERB Safety Glossary.

AERB REGULATORY DOCUMENT HIERARCHY

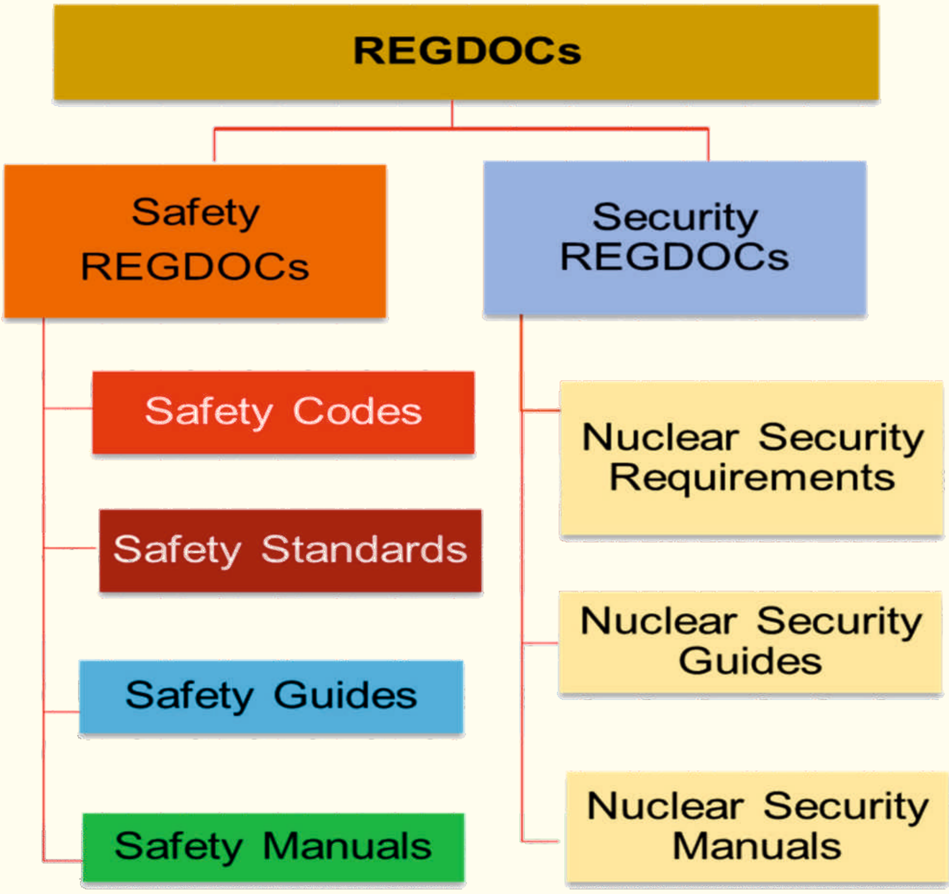
A hierarchy of REGDOCs has been established in AERB in order to ensure implementation of REGDOCs to achieve highest levels of safety without unduly affecting operation of the facility and conduct of an activity.

CATEGORIZATION OF AERB REGDOCS



Hierarchy of legislations, Regulations and Guidance

AERB's REGDOCs are broadly categorized as: Safety REGDOCs (e.g. Codes, Safety Standards, Safety Guides and Safety Manuals) and Security REGDOCs (e.g. Nuclear Security Requirements, Nuclear Security Guides and Nuclear Security Manuals). These REGDOCs are developed with a view that requirements and guidance covered therein are 'clear' and 'easily understandable' to the stakeholders and which adequately reflect regulatory expectations.



Categorization of REGDOCs

SAFETY CODE(S):

The Safety Code(s) specify minimum safety requirements that are required to be complied with by utility organizations for facilities and activities. These are approved by AERB Board and issued by Chairman, AERB.

SAFETY STANDARD(S):

Safety Standard(s) specify quantitative technical requirements on any particular aspect/ practice/ equipment. These include specific methods, specific formulae, particular empirical mathematical models, data libraries, computational aids and tools, standard graphs, curves and look-up tables etc. These are approved by AERB Board and issued by Chairman, AERB.

SAFETY GUIDES:

The Safety Guides elaborate various requirements specified in Safety Code(s) and Safety Standard(s) and furnish recommended approaches for their implementation. If utility adopts approach recommended by the guide, AERB review concentrates on compliance check. However, alternate approach adopted for satisfying the requirements, and thereby demonstrating the safety case, can be considered ‘acceptable’ with justification to the satisfaction of AERB. This requires elaborate review by AERB. Safety Guides may describe detailed explanation of approaches and methodology but they do not establish requirements and therefore they should not contain prescriptive ‘shall’ statements, in general. Safety Guides are approved and issued by Chairman, AERB.

SAFETY MANUALS:

Safety Manuals provide detailed technical approach/ methodology that can directly be applied while implementing a design/ feature of facilities and activities. The technical approach is derived from or based on relevant requirements specified in Safety Code(s)/ Safety Standard(s). Safety Manuals are approved and issued by Chairman, AERB.

NUCLEAR SECURITY REQUIREMENTS (NSR):

They are intended to set minimum requirements that are mandatory for the licensee to fulfill for providing adequate assurance for Nuclear Security. AERB may also adopt some of the International Standards and/or guidelines issued by some other ministries / departments of Government of India and make them as a part of NSR.

NUCLEAR SECURITY GUIDES (NSG):

They are intended to provide guidance and make available some of the methods for implementing specific requirements as prescribed in line with the relevant NSR(s).

NUCLEAR SECURITY MANUALS (NSM):

They are intended to elaborate specific aspects of Nuclear Security and may contain detailed technical information and/or procedures.

DEVELOPMENT PROCESS OF AERB REGULATORY SAFETY DOCUMENTS

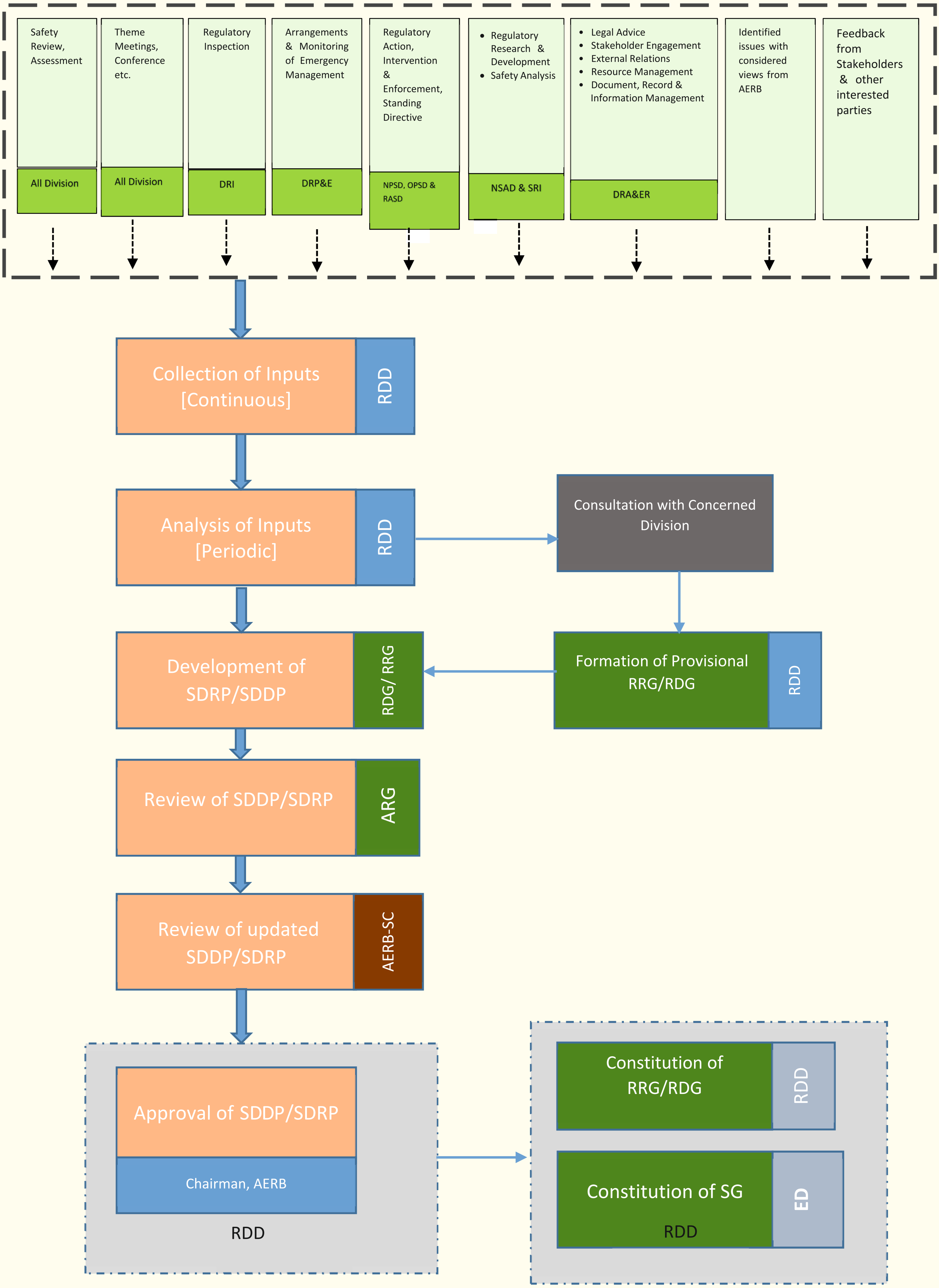
The AERB has established a dedicated division, Resources and Documentation Division (RDD), which is mandated with the responsibility of coordinating the process of development of regulatory documents in the AERB. The REGDOCs are developed as per the established process, which is evolved over a period of time taking insights from the regulatory experience and similar process adopted by International Atomic Energy Agency (IAEA). This process is consistent, clear, transparent, efficient, effective, and participative and is an inclusive process.

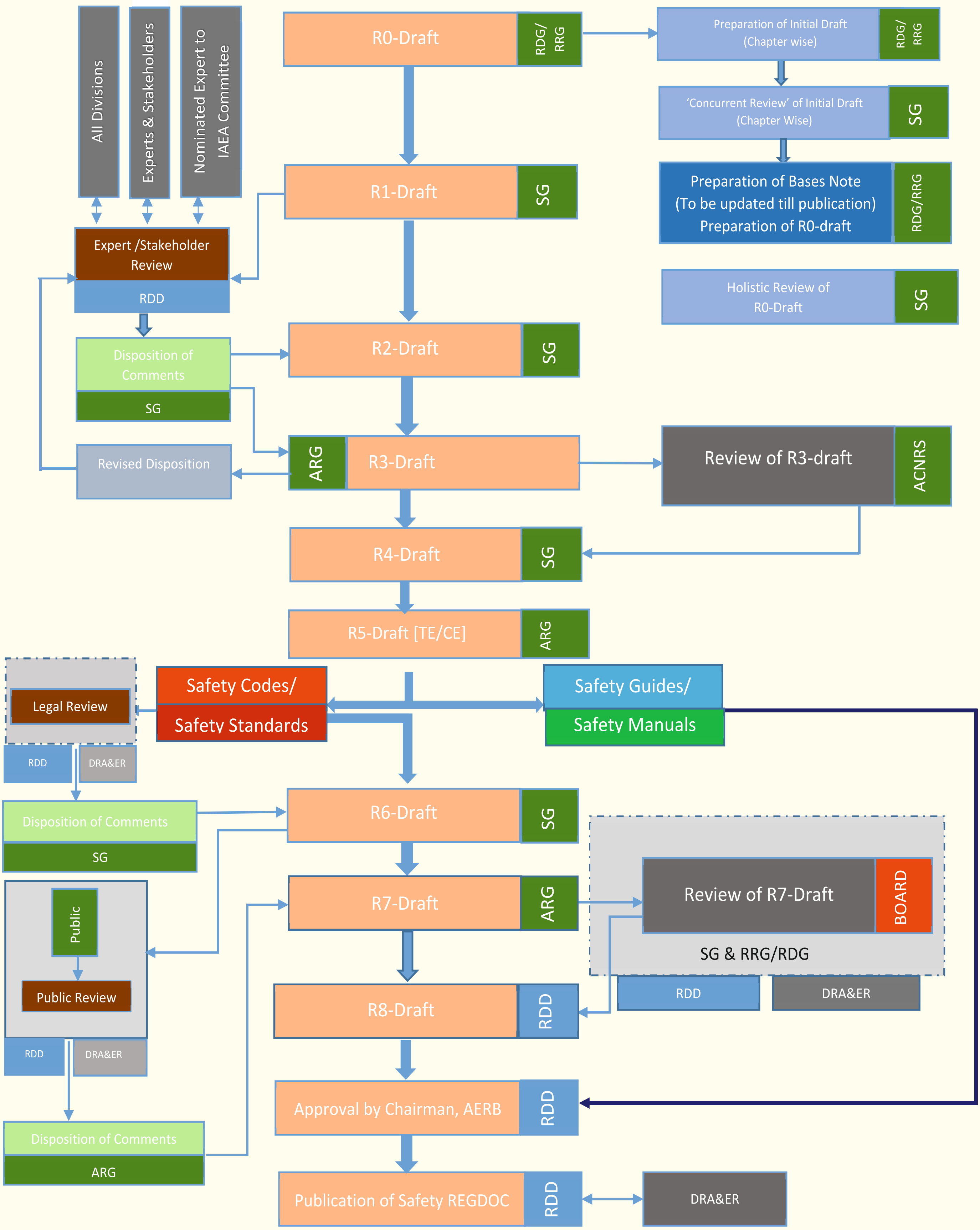
Experts, utility and interested parties are involved in the development of the regulations and guides by direct involvement as well as through comments and feedback throughout the development process. Technological advances, research and development work, relevant operational lessons learned and institutional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

The overall process can be divided into informal stages:

a) Planning stage; Steps 1-5
b) Preparation stage; Steps 6-7
c) Review stage; Steps 8-12
d) Approval stage; Steps 13-14

AERB's process of development of regulations and guidance for safety is shown below:


Safety Review, Assessment
All Division
Theme Meetings, Conference etc.
All Division
Regulatory Inspection
DRI
Arrangements & Monitoring of Emergency Management
DRP&E
Regulatory Action, Intervention & Enforcement, Standing Directive
NPSD, OPSD & RASD
Regulatory Research & Development
Safety Analysis
NSAD & SRI
Legal Advice
Stakeholder Engagement
External Relations
Resource Management
Document, Record & Information Management
DRA&ER
Identified issues with considered views from AERB
Feedback from Stakeholders & other interested parties
Collection of Inputs [Continuous]
RDD
Analysis of Inputs [Periodic]
RDD
Consultation with Concerned Division
Formation of Provisional RRG/RDG
RDD
Development of SDRP/SDDP
RDG/ RRG
Review of SDDP/SDRP
ARG
Review of updated SDDP/SDRP
AERB-SC
Approval of SDDP/SDRP
Chairman, AERB
RDD
Constitution of RRG/RDG
RDD
Constitution of SG
RDD
ED



REGDOC development and Revision process for Safety REGDOCs

PARTICIPATION OF PUBLIC AND INTERESTED PARTIES:

It is generally recognized that nuclear technologies contribute significantly to society through the generation of reliable, low-carbon electrical energy and in medical and industrial applications. However, concern over potential health effects of radiation often leads to public perception of risks that are much greater than the actual risks that experts attribute to nuclear technologies. Hence, one of the important function of a regulatory body is the communication and consultation with stakeholders and other interested parties throughout the lifetime of the facility or duration of the activity to both inform and obtain the views of the public and other interested parties. Therefore, AERB has instituted various mechanism to obtain public as well as interested party's comments and feedback. AERB invite public and interested party's comments on published REGDOCs and involved them during preparation or revision of REGDOCs, thereby ensuring their participation in the whole process.

RECENT INITIATIVES TAKEN BY AERB

AERB has taken certain initiative in recent times to ensure continued applicability and updating of its REGDOCs so that the requirements and guidance remains robust to potential changes in nuclear programme in near future. Some of these initiatives are:

a) AERB has prepared a long-term structure of AERB's Safety REGDOCs. This structure re-aligns published safety REGDOCs into two broad categories: (i) 'Thematic' safety REGDOCs, which are applicable to most of regulated facilities and activities, (ii) 'Specific' safety REGDOCs, which are applicable to specific Facilities or activities.

b) Developing of strategic plan for review and revision of safety REGDOCs in 'Campaign Mode', over next 5 years (i.e. October 2024 - December 2029). A total 135 safety REGDOCs have been published before the year 2014 and need to be revised. Out of these, 31 safety REGDOCs are currently being revised. Another 39 safety REGDOCs are being subsumed or identified for withdrawal due to recent initiatives taken in AERB such as harmonization of EP series, etc. Therefore, there are total 65 safety REGDOCs, which are required to be 'holistically' reviewed and updated or reaffirmed as part of the campaign mode.

c) Apart from this, AERB has initiated an activity of 'Harmonization' of Safety Codes to achieve the following:

   i) Safety Codes have a legal base/linkage with the published acts, rules i.e. no requirement is out of scope of mandate of AERB.

   ii) Harmony between requirements on particular area specified in multiple safety codes.

   iii) Need of guidance to be developed in compliance with the approved scope of the Safety Code.

   iv) Use of harmonized terminologies to minimize subjectivities.

d) Identification of areas where there is need to develop requirements and identification of requirements which need rethink in view of participation of JVs, PPPs and private entities in nuclear industry.

Following the top down approach, AERB has identified overarching requirements that required to be updated on a priority. This will enable AERB to regulate potential new entrants such as Joint Ventures and Licensee under the Public Privet partnership (PPP) model. This requires expeditious efforts for completing the review, revision and simultaneous approval of Safety Code on safety regulation of nuclear and radiation facilities & activities (AERB/SC/SR) along with guidance on consenting process for nuclear facilities as well as radiation facilities and activities, common code for radiation facilities (AERB/SC/RF) along with practice-specific guidance such as Industrial Radiography, Diagnostic Radiology, Container Scanner, Industrial Accelerator Radiation Processing Facilities, Medical Cyclotron Facilities, Nucleonic Gauges, Gamma Irradiation Chamber and Well Logging. Revision of Safety Code for Site Evaluation of Nuclear Facilities (AERB/NF/SC/S) is also being planned for ensuring coherency with emergency zones defined in recently published Safety Code on Nuclear and Radiological Emergencies (AERB/SC/NRE).

***

Licensing and Regulatory Oversight of Nuclear Power Plants in India

Rahul Porwal, C Nachiketa & S Harikumar

Nuclear Projects Safety Division
Atomic Energy Regulatory Board

1. Introduction

As of September 2024, India's installed electricity generation capacity has reached 452 GW, positioning it among the top five electricity producers globally[1]. The annual per capita electricity consumption for year 2021-22 was 1255 kWh[1]. Currently the share of nuclear power contributes to approximately 3% to India's total electricity generation[1].

India has been enhancing its nuclear power generation capacity, both through its ongoing domestic program focusing on Pressurized Heavy Water Reactor (PHWR) based Nuclear Power Plants (NPPs) and through foreign designed Light Water Reactors (LWRs). Presently, India operates 24 NPPs installed capacity of 8080 MWe[2]. This includes two Boiling Water Reactors located at Tarapur, twenty PHWRs (6 units at Rawatbhata, 4 at Kaiga, 4 at Kakrapar, and 2 units each at Kalpakkam, Narora, and Tarapur), and two Pressurized Water Reactors at Kudankulam. Eleven more units are currently under construction/commissioning, with a collective capacity of 8700 MWe. These include the 500 MWe Prototype Fast Breeder Reactor, two units of 700 MWe PHWR units each at Rawatbhata, Gorakhpur, and Kaiga, and four Pressurized Water Reactors of 1000 MWe each at Kudankulam. Moreover, Government of India has accorded administrative and financial approvals for the construction of eight additional NPPs with a combined capacity of 5600 MWe.

Safety is of paramount importance in the siting, design, construction, commissioning and operation of nuclear power plants. The overarching objective is to implement measures with the objectives of preventing accidents and mitigate their potential consequences, should they occur. This approach includes practically eliminating the accident scenarios that could lead to unacceptable radiological consequences. Should such events arise, however improbable, control measures are structured to terminate the event progression and manage the situation promptly, thereby safeguarding the public and occupational health by keeping the radioactivity confined.

2. AERB and its Regulatory Structure

The Atomic Energy Act, 1962, along with the associated Rules and Notifications issued under the Act, provide the legal framework governing use of ionizing radiation & nuclear energy in India. In addition to the Atomic Energy Act, compliance with other pertinent legislation related to environmental protection, land use etc. is required for establishment and operation of Nuclear Power Plants (NPPs).

India's regulatory framework for nuclear safety evolved in parallel with the development of its nuclear power program. Initially, safety regulation of research reactors followed a self-regulation approach, placing the responsibility of safety directly on the facilities. While this model proved effective initially, the expanding program highlighted the need for an independent mechanism to oversee the facilities. It led to the establishment of a safety review committee. With further expansion of the nuclear power program, a dedicated body

[1] Source: https://cea.nic.in

[2] Source: https://npcil.nic.in

for regulatory oversight was deemed essential, paving way to formation of the Atomic Energy Regulatory Board (AERB) in 1983 under the provisions of Atomic Energy Act of 1962, through a Presidential Gazette Notification.

AERB carries out regulatory and safety functions as per sections 16, 17 and 23 of the Atomic Energy Act, 1962. The mandate for AERB, brought out in the notification includes:

- Powers to lay down safety standards and frame rules and regulations with regard to the regulatory and safety requirements envisaged under the Atomic Energy Act, 1962.
- Powers of the Competent Authority to enforce Rules and regulations framed under the Atomic Energy Act, 1962 for radiation safety in the country.
- Authority to administer the provisions of the Factories Act, 1948 for the industrial safety of the units of DAE as per Section 23 of the Atomic Energy Act, 1962.

2.1. Structure of AERB

The Board

The AERB Board consists of a Chairman, five members, and a Secretary. The AERB Chairman also chairs the Board, while the Executive Director, AERB & Chairman of SARCOP is ex-officio member. The Secretary is an AERB employee, and members are distinguished individuals from government, academia, and national labs. The Board sets regulatory policies and makes key regulatory decisions. The Board is responsible to the Atomic Energy Commission (AEC). AERB provides the AEC with periodic updates on safety performance of the facilities and regulatory compliance, through presentation of Annual reports.

The Secretariat

The AERB Secretariat supports the Board's mandate, with the AERB Chairman overseeing its regulatory and administrative functions. The Chairman appoints an Executive Director to supervise the Secretariat. The AERB head office in Mumbai has technical divisions responsible for regulatory processes. The Regional offices (in Chennai, Kolkata and New Delhi) assist with the regulatory inspections, while the Safety Research Institute (SRI) in Kalpakkam conducts and coordinate safety research.

Committees of AERB

AERB obtain support from several committees for its safety review activities, with technical experts including from AERB, BARC, IGCAR, and academia. The norms for formation and functioning of these committees are part of AERB's integrated management system, which aims towards fostering strong in-house competence over time.

Key committees include the Safety Review Committee for Operating Plants (SARCOP) for operational safety review of nuclear facilities. Additionally, the Advisory Committee for Nuclear and Radiation Safety (ACNRS) reviews draft safety documents like Safety Codes and manuals, while the Advisory Committee on Project Safety Review of NPPs (ACPSR-NPP) advises on safety reviews and consents for new projects.

2.2. Multi-Tier Review Process

The safety committees work in tandem with the technical divisions to enable the safety reviews. The hierarchy of safety review committees helps AERB to carry out multi-tier review of the applications for regulatory consents.

The Nuclear Project Safety Division (NPSD) conducts in-depth reviews of design documents and oversees construction and commissioning, with support from other divisions. For operational NPPs, the Operating Plants Safety Division (OPSD) handles regulatory surveillance. The Directorate of Radiation Protection & Environment (DRP&E) provides expertise in the areas of radiological safety, effluent management, and emergency preparedness.

During siting, the initial reviews are conducted by Nuclear Projects Safety Division (NPSD), followed by the tier-1 committee, Site Evaluation Committee (SEC). Similarly for design, construction, and commissioning phases after the initial review by NPSD, the Project Design Safety Committee (PDSC) conduct the reviews (Tier-1). ACPSR, involving AERB, TSOs, and relevant agencies, performs the next review tier (Tier-2). Following ACPSR's review, the review outcomes and recommendations are considered by AERB for assessment. The Board of AERB forms the third tier, which considers the applications for grant of important consents, based on the safety assessments, for issuing consents. In operation phase, the initial reviews are performed by the Operating Plants Safety Division (OPSD) followed by concerned Unit Safety Committees (USC) and SARCOP which forms the tier-1 and tier-2 committees for operational safety reviews for oversight. SARCOP, as the tier-2 committee, advises the AERB Executive Director on safety matters. In addition there are specific Standing Committees and Expert Groups support targeted reviews for the identified technical areas, such as instrumentation & control, computer based safety systems, coolant channel safety, etc.

Operating on the principle of "management by exception," the above-mentioned multi-tier safety review process ensures that safety issues of higher significance are considered at higher-level for resolution. The recommendations of the committees are accepted by AERB for decision making after ensuring that they are in line with the safety goals, principles and requirements laid down by AERB.

3. Licensing of Nuclear Facilities

Chairman, AERB as the Competent Authority issues regulatory consents or licenses based on Sections 16 and 17 of the Atomic Energy Act, 1962, and relevant provisions from the Atomic Energy (Radiation Protection) Rules, 2004, the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987, and the Atomic Energy (Factories) Rules, 1996.

AERB's Safety Code on the 'Regulation of Nuclear and Radiation Facilities' (AERB/SC/G, 2000) outlines the minimum safety related requirements to be met by a nuclear or radiation facility to qualify for the issue of regulatory consent / licence at every stage during the life cycle of NPP. The Safety Guide 'Consenting Process for Nuclear Power Plants and Research Reactors' (AERB/NPP&RR/SG/G-1, 2007) specifies the regulatory consenting process, detailing the information submission requirements, review areas, etc.

During the different stages of NPPs viz. siting, design, construction, commissioning, and operation, the responsibility for safety is ensured through issuing consents and imposing conditions. The consents are issued based on review and assessment. The extent of review levels is decided, commensurate with the safety significance, following graded approach.

3.1. Regulatory Review Process for Consenting of new NPPs

The safety review process for consenting stages of a new NPP is summarized below:

3.1.1. Safety Review for Siting

The first consenting stage, Siting, involves reviewing site-related safety aspects as specified in AERB's Safety Code on Site Evaluation of Nuclear Facilities (AERB/NF/SC/S, Rev.1, 2014). This requires a Site Evaluation Report (SER) from the applicant, detailing the proposed site's features, design basis, site characteristics impacting safety, and the plant's impact on the surrounding population and the environment.

Key review aspects reviewed during Siting stage include geological, seismological, and meteorological site features, population distribution, land and water use, proximity to other infrastructures, water source availability, radiological impact, and emergency preparedness. AERB assesses if the site is suitable for safe NPP construction and operation, including establishment of "Exclusion Zone" and "Natural Growth Zone".

For siting of an NPP, in addition to the 'siting clearance' from AERB, the applicant is required to obtain clearances from the Ministry of Environment, Forests and Climate Change and other statutory bodies.

3.1.2. Safety Review for Construction

The second stage of consenting i.e. start of construction of the NPP requires a detailed safety review of the plant design and lay-out to ensure that plant meets safety and quality standards. During the reviews related to this consenting stage, the design of plant is assessed against the specified requirements, to reach a conclusion as to whether design is compatible with the Site conditions and it can be built to operate safely.

While applying for the construction consent, the applicant must perform a safety assessment to demonstrate compliance with the specified requirements and submit a Preliminary Safety Analysis Report, Quality Assurance manual, construction methodology documents, in line with AERB's requirements in relevant Safety Codes on Design[3] and Quality Assurance[4] and Safety Guides published thereunder. Additionally, the submissions need to include assessment of industrial safety measures, including Construction Safety Management and Job Hazard Analysis, in compliance with the Atomic Energy (Factories) Rules, 1996.

AERB may issue the consent for construction in one-go for the total construction activities or depending on the request from the applicant, in three sub stages viz. excavation, first pour of concrete and erection of major equipment. This scheme was devised to facilitate completion of detailed design safety review concurrently with the progress of project, making the regulatory process a bit more efficient in terms of time. However considering that nuclear technologies employed in India have reached sufficient maturity and the plans for large scale deployment, the preferred option will be that the design is standardised and AERB issues a single construction permission, after safety review of the site specific aspects.

3.1.3. Safety Review for Commissioning

NPP Commissioning is taken up after completing the plant construction in accordance with the approved design. The pre-commissioning activities may commence alongside the final construction phases, with

[3] AERB Safety Code on Design of PHWR based NPPs (AERB/NPP-PHWR/SC/D, Rev.-1, 2009); AERB Safety Code on Design of LWR based NPPs (AERB/NPP-LWR/SC/D, 2015)

[4] AERB Safety Code on Quality Assurance in Nuclear Power Plants (AERB/SC/QA, Rev.-1, 2009)

systems & equipment commissioned individually once the prerequisites are met. The initial regulatory clearance is required for integrated commissioning activities such as hot conditioning in PHWR-based NPPs or hot run in PWR-based NPPs. Further, the commissioning process involves multiple intermediate stages, each requiring review to ensure that the safety and technical requirements are met before advancing to the next phase. The start of nuclear commissioning i.e. the initial fuel loading (IFL), first approach to criticality, low power physics experiments and high power commissioning requires complete three tier review, up to the Board. The Safety review and assessment guidelines for NPP commissioning are specified in the relevant AERB Safety Guides[5].

AERB's review for commissioning consent entails a comprehensive assessment of final "as-built" NPP design. AERB confirms that (a) the plant adheres to the approved design and regulatory requirements, (b) the construction quality is verified, and (c) the safety evaluations and necessary tests for all pertinent systems have been completed satisfactorily. Additionally, AERB's assessments include availability of required trained and qualified personnel for operation, which have a bearing on safety.

3.2 *Regulatory Review of Operating NPPs*

3.2.1 *Safety Review for License for Operation*

The license for regular NPP operation is issued after a comprehensive review of plant performance, at rated power typically for around 100 days. To obtain this operating license, applicant must submit the Final Safety Analysis Report, which is updated with the results of commissioning and reflects the NPP's "as-built" design, along with the Technical Specifications for Operation and performance data from commissioning.

AERB reviews the submissions to confirm consistency with the design and adherence to established operational limits. Any discrepancies must be resolved to AERB's satisfaction before a license can be issued, allowing regular operation for up to five years.

3.2.2 *Safety Review during Operation*

Operation of nuclear installations in India is governed by the AERB Safety Code on 'Nuclear Power Plant Operation' (AERB/NPP/SC/O, Rev.1, 2008) and the Safety Guides issued thereunder. During regular operation, reviews are carried out to ensure that the operation of plant is being carried out in accordance with the approved Technical Specifications for Operation, AERB Safety Codes & Guides and the licensing conditions. This review covers (a) review of periodic reports submitted by the plant as per the specified reporting criteria including events/significant events, radiological safety status, radioactive waste management and radioactivity discharges to environment, (b) adherence to quality assurance and safety management aspects, (c) review of proposals for modification in hardware, control logics, plant configuration management, (d) results of surveillance and in-service inspection programmes and (e) regulatory inspections. In case of any deviations or non-compliances, AERB initiates appropriate enforcement actions, depending on the safety significance. The enforcement measures resorted to by AERB for such cases

[5] AERB/NPP&RR/SG/G-1, AERB/SG/O-4 and AERB/NPP-PWR/SG/O-4 C.

can range from issuance of written directives for ensuring compliance to the requirement to restrictive measures including curtailment/suspension of operation to suspension / revocation of the operating license.

An important consideration in this is operating experience feedback (OEF), wherein lessons learned from the experience elsewhere are utilized to effect appropriate safety enhancements. The feedback from Indian as well as overseas experience is utilized in this regard. AERB extensively uses the inputs from the International Reporting System (IRS) of IAEA in this regard. There has been a number of safety improvements carried out in the Indian NPPs in the past based on OEF. Such examples include Initiating a systematic life management programme for PHWR pressure tubes in 1983, improvements in fire protection measures following the turbine fire at NAPS in 1993, improvements in flood protection measures following the flooding incident at KAPP in 1994, inspection and health assessment efforts related to reactor core shrouds in the BWRs at TAPS, inspection and health assessment of the feeder pipes in the primary heat transport systems of all PHWRs, etc.

In addition to these AERB follows an approach of special reviews following events or developments of major safety significance anywhere in the world, to assess their impact on safety of Indian NPPs and need for any corrective actions. In the past, such special safety reviews were undertaken following major events like the Three Mile Island accident of 1979, the Chernobyl accident of 1986, the tsunami at the Madras Atomic Power Station (MAPS) in 2004 and the accident at the Fukushima Daiichi NPP in in 2011. These exercises have resulted in enhancements in the design of plant systems, safety management as well as regulatory requirements.

Safety review for renewal of operating licence

Licenses for operation are renewed following a Limited Scope Safety Review (LSSR) every five years. The renewal of licence requires conduct of Periodic Safety Review (PSR), typically once in every ten years, covering 14 safety factors, in accordance with the AERB Safety Guide 'Periodic Safety Review for Nuclear Power Plants (AERB/SG/O-12 Rev. 1)', and a limited scope safety review (LSSR) at the fifth year. Safety assessments during LSSRs cover four key factors viz. the actual condition of SSCs, safety performance, operating experience feedback, and the radiological impact on the environment. AERB reviews these assessments and considers renewal of license, once it is assured that the plant is capable of operating safely within the approved technical limits.

The safety assessments performed during the PSR take into account improvements in safety standards and operating practices, cumulative effects of plant ageing, modifications and feedback of operating experience etc., and involves comparison with the current safety standards / practices. As a part of this PSR, the hazard assessments are revisited with the latest available information. Through this process of PSR, strengths and shortcomings of the NPP against the requirements of current standards are identified, and the need for safety enhancements are identified and implemented.

The experience gained from the review of PSR of one NPP is also effectively utilised in reviewing PSR of the subsequent NPPs. This facilitate efficient and effective review of PSRs. All the operating NPPs in India have undergone

PSR, since the initiation of the PSR process in the early 2000s.

3.2.3. Safety Enhancements in Nuclear Power Plants

As brought out above, the combination of OEF, special safety reviews and PSRs have helped in implementing safety enhancements and strengthening of the requirements. The benefits accrued from this approach for safety enhancements could be seen during the safety assessment of Indian NPPs carried out following the accident at the Fukushima Daiichi NPP. The post Fukushima reviews have corroborated the inherent strengths in the design, operational and regulatory practices associated with the Indian NPPs. The post Fukushima strengthening measures identified for the Indian NPPs were associated mainly with (a) enhancing the resilience of the plants to cope with extreme external events exceeding the design bases and (b) to strengthen the provisions for mitigation of severe accidents.

4. Regulatory Inspection

AERB currently follows a comprehensive inspection process. The Division of Regulatory Inspection (DRI) is responsible for conducting the regulatory inspection program. DRI continuously evaluates the issues identified during the inspections, to improve the inspection process. Regulatory inspection strategies are designed to cover all consenting stages, ensuring NPPs meet regulatory requirements.

The inspection program is dynamic and includes routine inspections, as well as inspections prompted by safety reviews and previous findings. Inspections can be announced, unannounced Inspections involve examining the physical status of NPPs, reviewing procedures & records, and interviewing personnel. The frequency, scope, and depth of inspections are determined based on the safety significance of each consenting stage. Observations made during inspections are categorized based on safety significance and reviewed for necessary enforcement actions, if warranted. The inspection findings are utilised in the safety review process appropriately.

5. Dealing with New & Emerging Technologies

Currently with India poised for significant expansion in nuclear power capacity, involving NPPs of varying designs, including PHWRs, LWRs and FBRs, AERB is enhancing its capability to manage the consenting processes for diverse designs and technologies.

One of the significant aspects of AERB's capacity building is the development of regulatory requirements and guidance documents to facilitate the review and assessment of new designs. First of a kind (FOAK) systems pose a special challenge as they incorporate numerous engineered systems designed to prevent accidents and mitigate the consequences of design extension conditions. Since these systems are not be backed by adequate operational experience, they must be qualified through prototype or scaled experimentation and analysis to establish their 'basis of acceptance.' During safety reviews and assessments, such systems can be accepted after thorough justification through the review of experimental tests, and R&D reports. During commissioning, FOAK systems should be tested as far as practicable, to demonstrate their design intent. This proactive approach enables early detection of potential issues and implementation of corrective actions.

Safety assessments and regulatory reviews for the new reactor technologies, where AERB has not yet stipulated regulatory requirements or guidance, will be carried out with reference to relevant IAEA and other international safety standards. This approach enhances regulatory efficiency, as developing comprehensive regulatory safety documents indigenously requires adequate time and experience in the relevant technology. Furthermore, first-hand experience gained from reviews based on international safety standards provides crucial input for developing regulatory safety documents.

6. International Co-operation

AERB has a robust program for cooperation in the regulatory aspects of nuclear safety with numerous countries through both bilateral and multilateral platforms. Experts from AERB actively participate in various activities organized by the International Atomic Energy Agency (IAEA), focusing on safety and regulation. AERB experts contribute to numerous activities of the IAEA, the Organisation for Economic Co-operation and Development Nuclear Energy Agency (OECD-NEA), and other international forums.

Following India's ratification to the Convention on Nuclear Safety (CNS), AERB has taken the lead role in the CNS peer review process, serving as the nodal contact point for the country. The CNS peer review provides access to the national reports of the contracting parties of CNS which contain authentic information on the experience and practices of these countries as well as the issues and best practices. Since India began participating in the CNS peer review process in 2008, the national reports submitted for peer review under CNS during the three yearly review meetings are made available on AERB's website as a measure of transparency.

AERB’s regulatory processes were evaluated against the international benchmarks during the IAEA's Integrated Regulatory Review Service (IRRS) Mission in March, 2015. Since then, AERB has implemented various actions to address recommendations and suggestions from the IRRS Mission, including

strengthening its management system by implementing an Integrated Management System (IMS), reorganizing AERB for efficient resource utilization, enhancing regulatory inspection activities, and improving regulatory functions related to emergency preparedness and response. AERB hosted an IRRS follow up mission during June 2022, wherein the team had evaluated the progress on addressing the recommendations and suggestions from the 2015 mission. The reports on these IRRS missions are available on the website of AERB.

7. Looking Ahead

From the inception of India's nuclear program, key values have guided the regulatory system to maintain high safety standards. These include reliance on state-of-the-art scientific knowledge for regulatory requirements and decision-making, competent human resources, continuous learning for regulatory improvements, regular safety assessments, and considering stakeholders' views in regulatory decisions. These principles have been integral to the evolution of the AERB, helping it address past challenges.

Looking ahead, the nuclear power program is set for significant expansion, which will pose challenges in handling regulatory reviews and licensing diverse NPP designs, as well as long-term operation of existing NPPs. AERB is confident that adhering to these core values will enable it to rise to these upcoming challenges.

*****

Regulations in Radiation Applications and its Strengthening post Mayapuri Accident

Amit Sen, Alok Pandey*, Pankaj Tandon*and R.K. Singh
Radiation Applications Safety Division
*Directorate of Regulatory Affairs and External Relations
Atomic Energy Regulatory Board, Mumbai- 400094

1. INTRODUCTION

The applications of ionizing radiation sources (i.e. radioactive material and radiation generating equipment such as accelerators & x-ray machines) in various fields, viz., industry, medicine, agriculture, research and teaching have been significantly increasing all over the world including in India. Since 1950s there has been steady growth of applications of radiation sources in the country. At the same time, it has been recognized to ensure the radiation safety and physical security of these sources for ensuring a high standard of safety and reliability in handling of radiation ensures control over radiation material throughout their life-cycle. The Atomic Energy Act 1962, for development, control, and use of atomic energy for the welfare of people and for other peaceful applications forms the main basis of the regulatory framework. AERB enforces the provisions of the Atomic Energy (Radiation Protection) Rules, 2004 and other relevant rules issued under the Atomic Energy Act, 1962 and the Safety Codes, Standards, Directives for safety regulations in the country.

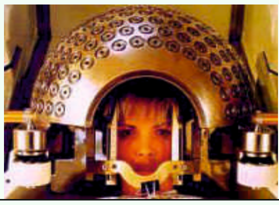
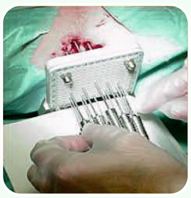
2. APPLICATIONS OF RADIATION SOURCES

The use of radiation sources include in the field of radiation processing for food

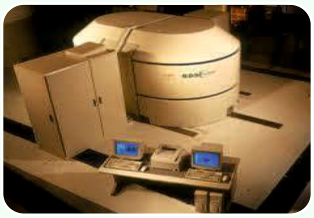
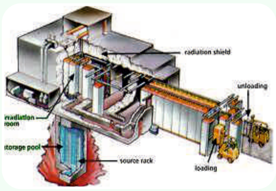
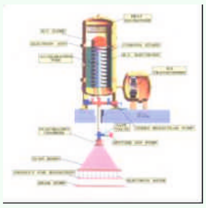
sources through their careful design. This can be achieved by ensuring adequate built-in-safety, safe operation & periodic maintenance procedures, safe transport, secure storage, physical security to radiation sources at all times, availability of emergency response plans & preparedness, and ensuring safe disposal of disused sources. The licensee of the radiation facility is having overall responsibility for ensuring safety and security of radiation sources. The legal, administrative and regulatory framework in India have the necessary provisions such that the safety and security of radioactive sources receives the necessary regulatory coverage and

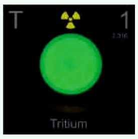
preservation; sterilization of healthcare products; radiotherapy installations for treatment of cancer; nuclear medicine for diagnosis and therapy; diagnostic radiology (medical X-ray, CT, interventional radiology etc.), gamma irradiation chambers / blood irradiators for several R & D studies and irradiation blood components; industrial radiography for non-destructive examinations of steel structures, welds/joints; industrial ionizing radiation gauging devices for monitoring/ measurement of on-line quality control parameters (e.g. thickness, level, density, moisture, elemental analysis); consumer products such as radioluminous timepiece, gaseous tritium light sources (GTLS), gaseous tritium light devices (GTLD), ionization chamber smoke detectors (ICSD), fluorescent light starters, antistatic devices and incandescent gas mantles containing thorium. All these beneficial applications involve the use of both sealed and unsealed radioactive sources and amount of radioactivity varies from few kBq (µCi) to hundreds of TBq (thousands of Ci).

2.1.Various applications of radiation sources

MEDICAL	
Teletherapy 	In teletherapy (branch of Radiotherapy), radiation is used to treat malignancy. The radioisotopes like, ^{60}Co,. and radiation generators like Linear Accelerators are used.
Gamma Knife 	Gamma-knife is used for treatment of small sized brain tumors. It has around 192 to 201 ^{60}Cosources, focusing gamma rays from each source on the tumor by using circular collimators of different sizes.
Medical Linear Accelerators 	Linear Accelerator (LINAC) uses high-frequency electromagnetic waves to accelerate electrons to high energies through a linear tube. The high-energy electron beam itself can be used for treating superficial tumors, or it can be made to strike a target to produce x-rays for treating deep-seated tumors.
Proton Therapy 	Proton therapy units are in operation having in built cyclotron with typical proton beam energy varying from 70 MeV to 250 MeV. It is the most popular particle therapy that uses a beam of protons for treatment of cancer. The advantage of proton therapy over other types of external beam radiation therapy is, being a charged particle, the proton dose is deposited over a narrow range of depth resulting no exit dose and less dose to the tissue surrounding the tumor.
Brachytherapy  	In brachytherapy (branch of radiotherapy in which the source is kept very near to the lesion) the isotopes used are^{192}Ir, ^{137}Cs, ^{90}Sr, ^{106}Ru, ^{125}I with activity range in MBq (mCi) to GBq (Ci).

Plaque Brachytherapy 	**Plaque Brachytherapy:** An efficient approach for treatment of medium sized melanoma, retinoblastoma and choroidal melanomas. Radioactive source as Iodine-125, Palladium-103 and Ruthenium-106 are being used for this treatment.
Diagnostic Radiology Cath Lab: 	X-rays are used in Medicine as an important diagnostic tool.The fundamental goal in diagnostic radiology is to obtain good quality images at optimum patient dose. Diagnostic Radiology using x-rays are- • *Interventional Radiology equipment(Cath Lab)*: This equipment is used in operation theatres for various interventional procedures and are of high to moderate radiation hazard potential to patients and medical professionals operating the equipment.
Computed Tomography 	*Computed Tomography:* This equipment is used to generate the computed tomograph of the organ to view the 3-D image of the organ after the processing.
Radiography and Fluroscopy 	• *General purpose radiography and fluoroscopyequipment, and dental equipment:* Theseconstitute around 70-80% of all x-ray equipment that are used for diagnostic purposes.
Mammography 	• *Mammography:* This equipment is of very low radiation hazard potential.It is commonly used to diagnose breast-cancer.
Dental x-ray Imaging  	**Dental X-ray:** This equipment is used in the dental department to take the image of teeth by using x-rays. Radiation dose received by a patient in intraoral radiography is negligible but collective doses cannot be ignored due to high number of examinations.

Medical Cyclotron 	Usually the radioisotopes are produced in research reactors, but some radioisotopes that are used in Nuclear Medicine are also produced from Medical Cyclotron facilities.
Nuclear Medicine  	In Nuclear Medicine, Radio-pharmaceuticals using radionuclides such as ^{99m}Tc, ^{131}I, ^{201}Tl and ^{18}F are used for diagnosis and treatment.
INDUSTRIAL	
Radiation Processing **GRAPF**  **IARPF** 	Radiation Processing Facilities (RPF) includes Gamma Radiation Processing Facilities (GRAPF) and Industrial Accelerator Radiation Processing Facilities (IARPF), which are used mainly for sterilisation of healthcare products, cross linking of polymers in cable industries. Some of the facilities are also used for radiation processing of food items for various purposes such as inhibit sprouting, delay in ripening, microbial decontamination, Insect disinfestation, shelf life extension etc. Generally Co-60 source isused for this purpose in the activity range of about few PBq(~10^6Ci).
Industrial Radiography 	Industrial radiography is one of the important non-destructive methods used for inspection of weld joints, castings etc. Radioisotopes like ^{192}Ir, ^{60}Co,^{170}Tm, ^{75}Se and different energies of X-rays are being are used in the field of industrial radiography. The activity range is from few TBq (few tens of Ci) to few tens of TBq (few hundreds of Ci). The X-ray energy range is from few hundreds of keV to few MeV.
GIC / Blood Irradiators 	Gamma Irradiation Chambers (GIC) are used for irradiation of blood and for research purposes. Usually ^{60}Co radioisotope is used in this application. The activity range from few tens of TBq to few hundreds of TBq.

Nucleonic Gauges (NG) 	The nucleonic gauges are used for online monitoring of quality control parameters such as thickness, level, density, coating thickness, elemental analysis etc. Sources used for nucleonic gauges includes gamma sources such as ^{60}Co, ^{137}Cs, ^{241}Am etc., beta sources such as ^{90}Sr, ^{85}Kr, ^{147}Pm, ^{204}Tl etc and neutron sources such as Am-241-Be. The activity range is from MBq (mCi) to GBq (Ci).
Well logging (WL) 	Radioactive sources are used in well logging (WL) application for exploration of oil, coal, geophysical logging etc. The sources used are mainly ^{137}Cs, Am-241-Be, and some calibration sources such as ^{60}Co, ^{226}Ra, ^{232}Th etc. and neutron generator e.g. Deuterium-Tritium Generators etc. The activity range is from kBq (µCi) to GBq (Ci).
Consumer products  	A consumer product is a manufactured product or item containing very small amount of radioactive substance, which is exempted at the end user level from regulatory control. However, the manufacturing and distribution of the products in bulk require Licence from the regulatory body.

3. REGULATORY FRAMEWORK

The Atomic Energy Act of 1962 enacted by the Government of India provides the basic regulatory framework for all the activities including health and safety concerning the atomic energy programme in India. The use of radioactive material and radiation generating equipment is governed by the said Act. Section 16 and 17 of the Act empowers the Atomic Energy Regulatory Board (AERB) to exercise control over radioactive material and radiation generating equipment. Accordingly, AERB's written consent is required for the manufacture, possession, use, transfer by sale or otherwise, export and import, transport and disposal of any radioactive substance.

3.1. Atomic Energy Regulatory Board

The Government of India has constituted the Atomic Energy Regulatory Board in 1983, as the national regulatory authority to carry out certain regulatory and safety functions envisaged under the Act. The *Chairman, AERB is the Competent Authority to enforce provisions for radiation safety in India.*The mission of AERB is to ensure that the use of ionizing radiation and nuclear energy in India does not cause unacceptable impact on the health of workers, members of the public and on the environment. AERB has powers to lay down safety standards, frame rules and regulations with regard to regulatory and safety requirements envisaged under the Act. AERB is also mandated to develop practice specific Safety Codes, Standards, Guides for design & construction, commissioning, operation including decommissioning of different radiation installations and to verify the compliance with requirements of safety Codes and Standards. AERB exercises safety regulations over radiation installations by enforcing provisions of the following:

- Atomic Energy Act, 1962.
- Atomic Energy (Radiation Protection) Rules {AE (RP) R}, 2004.
- Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987.
- AERB Safety Standards and Safety Codes for radiation practices and equipment including transport of radioactive material.

AERB issues licence under AE(RP)R, 2004 for handling of radiation sources including routine operation of radiation facilities. The licence stipulates different conditions to be complied with by the licensee such as submission of periodic safety status reports to AERB; use of type approved equipment; reporting of emergency incidents to the competent authority etc.

4. SAFETY REGULATIONS

AERB exercises safety regulations over radiation facilities viz. radiation processing plants (RPPs), radiotherapy, nuclear medicine, diagnostic radiology, gamma irradiation chambers, industrial radiography, nucleonic gauge, research and academic institutes etc. These facilities, having a wide range of sources and devices, which require detailed review for issuance of regulatory Consent. The hazard potential in these sources varies from low to high potential and the pre-requisites for issuance of regulatory consent varies. Accordingly, the consents are graded ranging from a 'Licence' for high hazard potential sources to a ‘Registration’ for low hazard potential sources. The regulatory measures taken to ensure effective management of radioactive sources are implemented mainly in three stages viz, pre-licensing, during useful life and safe disposal of radiation sources.

4.1 Pre-licensing stage

Pre licensing stage includes

- Type Approval of sources and radiation equipment.
- Approval of safe and secure source storage facility.
- Availability of suitable radiation monitoring instruments (area / personal).
- Availability of qualified, trained and certified manpower.
- Availability of emergency response plans and security plan.
- Commitment by the radiation facilities to return disused sources to original supplier

4.2 During the useful life

Under terms and conditions of the licence, each licensee is required to submit periodic safety reports to AERB regarding the radiological safety status by confirming safe handling and secure management of radiation sources in their possession. Safety and security measures are verified by carrying out regulatory inspection (periodic and special inspection) at radiation facilities by AERB.

4.3 After the useful life

Once the useful life of the source is over, the licensee is required to make arrangements for safe disposal of the disused sources by obtaining prior approval from AERB. For this purpose, institution is required to make financial arrangement for the safe management of the disused sources.

5. RADIATION SAFETY

Radiation safety aims at control of exposure both under normal operations and as a consequence of potential accidental exposure situations. The primary means of ensuring safety under normal operation is by controlling exposures through biological shields, distance or time restrictions. The primary means for preventing potential accidental exposures is by good engineering design of installation and equipment and good operating procedures. Safety is achieved by built-in safety combined with operational safety. The components of built-in safety includes design of the sources, packages, equipment and installations as per the national / international standards.
Moreover, components of operational safety includes the following;

- Strict adherence to standard operating procedures (SOPs)
- Operation by qualified and certified man power in radiation facility
- Work place monitoring
- Personnel monitoring services for radiation workers
- Safe and secure storage of the radioactive sources when not in use
- Use of appropriate safety accessories
- Inventory of all radioactive sources
- Emergency planning and preparedness
- Effective management
- Good work practice

5.1. Training & Safety Awareness

There is regulatory requirement of availability of radiation safety trained manpower for handling radiation sources. Such required manpower is developed through various training courses on radiation safety, which include courses for Radiological Safety Officer (RSO) and operator / technologist. At present, these courses are periodically conducted by BARC in collaboration with professional bodies and recognized training institutes.

In addition, AERB regularly conducts awareness programmes on safety and security of radioactive sources for the radiation facilities, suppliers of radiation devices / sources, customs, airport authorities, and public. Moreover, AERB interacts with the professional bodies and stakeholders to obtains inputs on matters related to training programme.

5.2. Health Surveillance & Medical Examination of Radiation Workers

It is the responsibility of employer to provide occupational health surveillance to radiation workers. Every radiation worker, initially on employment and classified worker, thereafter at least once in three years shall be subjected to general medical examination and occupational health surveillance. It is the responsibility of employer to provide personnel monitoring and arrange health surveillance for radiation workers and furnish to each worker dose records and health surveillance reports annually or as and when requested by the worker and at the termination of his employment.

6. e-GOVERNANCE SYSTEM OF AERB

AERB has implemented web-based system, e-LORA (e-Licensing of Radiation Applications) through automation of regulatory processes associated with the use of ionizing radiation in India. This system maintains a computerized national register of sealed radioactive sources as well as radiation generating equipments and enhanced robustness in the data base and further efficiency and transparency in the whole regulatory process with automation and real time management of regulatory processes for various types of radiation facilities located across the country.

7. DECOMMISSIONING AND DISPOSAL OF DISUSED SOURCES

When the radioactive sources are no longer in use, the licensee initiates immediate action for its safe disposal/decommissioning. The licensee obtains prior approval from the Competent Authority for decommissioning of radiation facility and disposal of the disused sources as per the Atomic Energy (Safe Disposal of Radioactive Sources) Rules, 1987

8. SECURITY OF RADIOACTIVE SOURCES

It should be ensured by users that radioactive sources are secured at all the time so as to prevent theft or damage and to prevent any unauthorized handling, access to sources. It is necessary that periodic inventory of fixed and moveable sources is carried out to confirm that they are in their authorized locations and are secure. For addressing the security requirements, AERB has published security related regulatory documents.

Security is a prerequisite for safety, almost all the measures required to ensure safety while handling radioactive sources are applicable to their security too. However, security measures should be seen as an integrated concept involving industrial safety arrangements and radiation protection measures.

Security of packages of radioactive material during transport should be ensured by the consignor by implementation of various security measures such as use of source storage container, exclusive vehicles, proper instructions to the carrier, tracking of the shipment etc.

9. INCIDENT INVOLVING RADIATION SOURCES

Ionizing radiation sources if not handled safely, may lead to exposures to an unacceptable hazard. There were few instances of unsafe work procedures and unusual incidents involving radiation sources, reported to AERB in the past.

9.1. Mayapuri Accident

Though, there is good track record on safety regulations of radiation sources in India, an untoward accident happened in April 2010 in Mayapuri Industrial area, Delhi involving radioactive source (un-authorised dismantling of a disused gamma cell), where a person succumbed due to radiation injury. The Mayapuri accident stands as a stark reminder to the need for continuous vigilance, knowledge dissemination and diligence in preserving public safety and averting potential disasters.

9.2. Strengthening regulatory aspects-post Mayapuri

Post Mayapuri accident, AERB took a comprehensive re-evaluation and strengthens the safety regulations in the country. The incident was an eye opener as it triggered a nationwide awakening regarding the importance of stringent radiation safety protocols and their effective enforcement with regard to use of radiation sources in medical, research and industrial fields.

The following measures were initiated to prevent future incidents:

- Sensitizing academic, medical, research and industrial institutions to undertake comprehensive inventories of radiation sources in their possession.
- Integration of radiation emergency management into medical education curricula was emphasized to ensure comprehensive preparedness.
- Public awareness regarding legal, regulatory and safety requirements related to radioactive sources. This was achieved through the issuance of notices via print media and knowledge sharing on AERB website.
- Strengthening of Regional Regulatory Centres (RRCs) located in Kolkata, Chennai and New Delhi and enhancing the numbers of regulatory inspections of radiation facilities.
- Establishment of online system for e-Licensing of Radiation Applications (eLORA) for licensing of radiation facilities.
- Establishing coordination with relevant ministries to install radiation detection equipment at sea ports, and mobilizing the metal recycling industry to incorporate radiation monitoring equipment in scrap processing.

The Mayapuri incident was a turning point for all as it reminded the need for rigorous safety practices in dealing with radiation sources. AERB's proactive response transformed it into an opportunity to enhance radiation safety practices especially with respect to management of disused radiation sources.

10. CONCLUSION

The multifarious applications of radiation sources for immense benefits of the society. Overall radiation protection of personnel and safety in use of radiation sources is a function of inherent built-in safety features and safe operating and maintenance procedures. Radiation exposures during normal operations are controlled by application of system of dose limitations. Emergency planning and preparedness helps in mitigating the consequences in case of unusual occurrences. Nevertheless, the primary responsibility for ensuring safety and security of radiation sources rests with the licensee of the radiation facility. AERB is committed to suitably incorporating the best practices in the area of safety and security of radioactive sources in its administrative and regulatory framework and continuous improvements are made based on experience gained and new developments.

Changes in the Framework of Emergency Preparedness and Response after the Fukushima Accident

S.P. Lakshmanan, Krishna Reddy, Ritu Raj, S.K. Dubey and Kapil Deo Singh
Division of Radiation Protection & Environment
Atomic Energy Regulatory Board
spl@aerb.gov.in

The Fukushima Daiichi nuclear accident of 2011 in Japan altered the landscape of Emergency Preparedness and Response (EPR) for nuclear and radiological emergencies worldwide. The event, caused by a tsunami following a massive earthquake, led to reactor meltdowns and release of radioactive material to environment. The accident brought light on several gaps in the nuclear safety framework, and as a result, governments, regulatory bodies, and international organizations, such as the International Atomic Energy Agency (IAEA), revised their approach for managing nuclear and radiological emergencies. India's approach to nuclear emergency preparedness and response also underwent significant change to enhance the resilience of its nuclear infrastructure and improve the country's readiness to respond to nuclear emergency.

A comprehensive review to enhance the safety of Indian NPPs were carried out by dedicated expert committees. These reviews focused on evaluating plant safety against extreme natural events like earthquakes, tsunamis, and floods. Based on these review, several improvements in plant design incorporating/strengthening additional & complimentary safety features have been achieved including enhancements in the arrangements related to emergency preparedness and response. Key changes envisaged in India's EPR framework post-Fukushima event covering regulatory requirements, role and responsibilities of operating organisations, response organisations, stake holders and regulatory body are dealt in this article.

Revised Regulatory Requirements

AERB reviewed the then existing requirements in light of the following:-

- Consolidation of existing requirements that were published over a wide timeline {EPR chapter in Safety Code on Operation (AERB/NPP/SC/O Rev. 1), AERB guidelines on preparation of on-site and Off-site EPR Plans for nuclear installations (AERB/SG/EP-1 and EP-2), AERB safety guide on preparedness of the operating organisation for handling emergencies at nuclear power plants (AERB/SG/O-6) and role of the regulatory body with respect to emergency preparedness and response at nuclear and radiation facilities (AERB/SG/G-5)}.
- Inconsistency among these REGDOCs;
- Recent changes in IAEA approach & publications, lessons from Fukushima Accident and feedback from IRRS Mission to AERB;
- Feedback from existing practice and experience gained through oversight of emergency exercises;

- Publication of National Disaster Management Plan (NDMP) by National Disaster Management Authority (NDMA) in 2016 (revised in 2019), and the responsibility assigned to AERB to establish requirements and guidance, comprehensively covering the activities carried out by various stakeholders including National (NDMA, NDRF etc.), State (SDMA, SDRF etc.) and District Authorities (DDMA) involved in the management of Nuclear and Radiological Emergency (NRE).

Based on the above envisaged changes AERB updated the regulatory requirements through publishing a dedicated safety code on management of nuclear and radiological emergencies (AERB/NRF/SC/NRE), with focus on requirements related to the area of hazard assessment, declaration and notification of emergency, protection strategy, protection of emergency worker, termination of emergency, communication strategy, roles and responsibilities, response facilities, training and emergency exercises, among others. Relevant regulatory guidance for nuclear facilities, radiation facilities and radiation emergency during transport are under various stages of development (AERB/NF/SG/NRE-1, AERB/RF/SG/NRE-2 and AERB/NRF-TS/SG/NRE-3). The revised requirements were evolved following a bottom to top approach. Various technical documents were developed on key areas (Initiating Condition and Emergency Action Level (IC&EAL), early phase protection strategies, methodology for conduct of off-site emergency exercise etc.). Stakeholder were consulted and interim instructions were given to utility for implementation and their feedback before finalizing the regulatory requirements and guidance.

Restructuring of Response Framework

For management of nuclear and radiological emergencies, timely and effective implementation of response actions is essential. This is achieved through clearly assigned roles and responsibilities and a coordinated response framework.

The requirement for institutional framework have been revised taking into account current development for responding to an emergency involving various agencies (operating organisation, response organisation, local, state and national level authorities). The revised framework takes cognizance of the characteristic of different phases following an accident, in terms of early, intermediate and late phase. During early phase, major radioactive releases into the environment occur and various urgent protective actions (sheltering, ITB and evacuation etc.) need to be taken promptly in order to avoid severe deterministic effect or reduce risk of stochastic effects. In the intermediate phase, further significant accidental releases are unlikely and early protective actions (Food control and relocation etc.) needs to be implemented based on field measurements and survey.

The revised response framework addresses coordination between the various response organizations (NPP, DAE-CMG & RERD) and interface with local authorities. This has been evolved through consultation among utility, CMG-DAE, NDMA and AERB.

National Disaster Management Authority (NDMA) established in 2005 under the provisions of Disaster Management Act, 2005 is the apex body for laying down the policies, plans, and guidelines for disaster management for ensuring timely and effective response actions.

Department of Atomic Energy (DAE) is the nodal department for technical support during management of nuclear or radiological emergencies. DAE coordinates its actions through the Crisis Management Group-DAE (CMG-DAE) at the national level.

District authority is responsible for implementing protective action in public domain. They are assisted by response forces (like NDRF), armed forces, other uniformed services and government organizations / agencies as necessary during the response.

As part of the revised response structure, the Site Emergency Director (SED) is responsible for taking response action at site and advising/recommending public protective actions to District Authorities during the early phase, which will be in accordance to the prevailing plant and weather conditions. Radiation Emergency Response Director (RERD) of DAE is responsible for advising/recommending public protective actions to District Authorities during the intermediate phase based on field measurements and sampling and also for termination of emergency.

Revision of off-site EPR plan

A major change post-Fukushima was a renewed focus on integrating the off-site EPR plan of district authorities with District Disaster Management Plans (DDMPs) which is in line with DM Act, 2005, NDMP-2016 (revised in 2019) and the Incident Response System (IRS) issued by NDMA. District Authorities maintain an off-Site EPR Plan as part of the integrated DDMP covering response action in the public domain.

NPPs have their individual Off-Site EPR Plan covering their responsibilities. This plan address the aspects of classification, declaration and notification of emergency; principles for planning and implementation of protective measures; public communication; testing of all emergency response functions over a determined period of time; comprehensive list of procedures for implementation of the emergency response plans; operational control and responsibility for personal protection of external services when they are at the facility. AERB approved the template of the EPR plan bringing out the expectation and the arrangements that needs to be in place and asked for revision of the off-site EPR plan of the utility in accordance with that, incorporating the new requirements.

Revamped off-site emergency Exercise Framework

Review of then existing practice and Stakeholder feedback indicated the need for strengthening the emergency exercise framework. In order to comprehensively address all exercise objectives and to address the gap areas identified through systematic mapping against the existing practice, a scheme having modular and integrated approach with different types of exercise viz. Table-top (TT), Integrated Command Control and Response (ICCR) and Field Exercises and Demonstration (FED) was made. As per the revised methodology, the exercises are to be conducted such that the scenario for the exercise is only revealed gradually through injects given from time to time during the exercise. Exercises are conducted as per the identified frequency with the participation of utility, local authorities and DAE within the scope of the exercise. AERB and NDMA oversee the respective off-site emergency exercises and some of these exercises are evaluated by Regulatory body.

Improved Event Identification and Notification Protocols

Based on the revised requirements for identification, notification and activation of emergency response, utility have to ensure that emergency conditions are promptly identified and notified to concerned response agencies. In order to enable a prompt identification of emergency conditions, an emergency classification system (Emergency alert, plant, site and off-site emergency) based on plant conditions in terms of Emergency Action Levels (EALs) have been instituted. The system ensures that the local authorities are promptly notified for activation of response and public receives timely instructions from local authorities on taking protective actions such as (sheltering, food control, Iodine thyroid blocking, evacuation etc.). Clear and timely dissemination of information for taking effective protective actions to all response organisations and the regulatory body during a nuclear emergency is now a priority.

Tools to Support Emergency Decision Making - DSS:

Aimed at enhancing decision-making during nuclear emergencies, an integrated real-time online Decision Support System (DSS) is required to be deployed at all NPP stations. These systems facilitate in prediction of the possible radioactive releases and map radiation dispersion using predicted weather conditions. Further predicted concentration, dose and response actions are overlaid with critical information like population density, evacuation routes, and infrastructure using a Geographical Information System (GIS). This would improve the decision-making for effective response actions.

On-site Emergency Support Centre and District Emergency Operation Centre

Based on the safety review undertaken after Fukushima accident, it was identified that an Onsite Emergency Support Centre (OESC) needs to be established at all NPP sites. AERB has framed requirements and guidelines for establishing OESCs. This facility is required to have the capability to withstand earthquake and flood of magnitudes larger than their respective design basis for the NPP. The building is designed with requisite shielding for protected stay of response personnel for extended duration. It is also equipped with a safety parameter display system, which provides a display of plant parameters from which the safety status of plant may be assessed.

Following an all-hazard approach, off-site response is to be executed from District Emergency Operating Centre (DEOC) which was earlier supposed to be carried out from the Off-site emergency control centre located at township of NPP.

Justified and Optimized Protection Strategy for Nuclear Emergencies

The Fukushima accident highlighted the importance of carefully optimizing emergency response actions, as response efforts can sometimes result in more harm than good. This has led to a shift in approach, where early phase decision-making and optimization play a central role in emergency management.

Previously, protective actions were to be implemented based on predefined intervention levels, with equal emphasis on all actions regardless of their impact on public life. However, the current approach focuses on considering all exposure pathways and evaluating protection options to determine the more effective course of action within a comprehensive protection strategy. Protection strategies include consideration to health effects of radiation (deterministic and stochastic effects), non-radiological consequences, reference dose level, generic criteria and operational criteria (IC&EAL and OIL).

A methodology has been developed for formulating an optimized protection strategy, considering multiple factors such as plant condition, terrain, and weather. This approach also identifies site-specific emergency planning zones, including the Precautionary Action Zone (PAZ) and Urgent Protective Action Zone (UPZ).

By combining pre-identified emergency planning zones with protection strategies tailored to the prevailing conditions so that public protective actions result in more good than harm. This framework is now being used by utilities to develop site-specific arrangements and protection strategies for inclusion in their emergency preparedness and response plans.

Establishment of Nuclear and Radiological Emergency Monitoring Centre

During an emergency, regulatory body is responsible for keeping itself apprised of situation, review of response actions and inform public as and when necessary. During a nuclear or radiological emergency, it is crucial for the Atomic Energy Regulatory Board (AERB) to have real-time information about the situation, the safety of emergency workers, and the protection of the public. To support this, AERB established the Nuclear and Radiological Emergency Monitoring Centre (NREMC).

During an emergency, AERB monitoring activities are carried out and coordinated from Nuclear and Radiological Emergency Monitoring Centre (NREMC). The Centre has various cells for Communication, Assessment, Analysis and public information along with necessary software and hardware infrastructure. The capabilities of NREMC include emergency analysis, assessment of emergency response actions & protective actions and communication with various Stakeholders.

Conclusion

In the aftermath of the Fukushima nuclear accident, significant progress has been made in strengthening Emergency Preparedness and Response framework. This is achieved through changes in key areas encompassing revision of regulatory requirements, restructuring of response framework along with clear roles and responsibilities, development and deployment of decision support system, among others. A comprehensive off-site emergency exercise program is instituted by introducing modular and integrated type of exercises.

A systematic bottom to top approach was followed, wherein the revised EPR arrangements could be demonstrated and tested through exercises to obtain feedback before finalisation. The major focus was to establish an EPR structure that can ensure prompt implementation of justified protective actions resulting in more good than harm with due considerations to non-radiological consequences. These efforts underscore commitment to ensuring the highest levels of safety.

AERB Activities towards Enhancement of Public Trust and Stakeholder Engagement

Anuradha V, Soumen Sinha, A.P.Garg
Directorate of Regulatory Affairs and External Relations
Atomic Energy Regulatory Board
Mumbai-400094

Introduction

Stakeholder is any group or individual who feels affected by an activity, whether physically or emotionally. Stakeholder engagement has been identified as one of the nineteen infrastructure issues covered in the IAEA's milestone approach, a structured methodology used by the member states for development of infrastructure for a new or expanding nuclear power programme. Stakeholder engagement in a nuclear programme and throughout the life cycle of nuclear facilities is best achieved through open dialogue between government, regulatory body, owner, operator and other stakeholders, whether they be institutions or individuals. The key principles of stakeholder engagement are building trust, demonstrating accountability, exhibiting open and transparent communication, open and frequent consultations, and communicating benefits and risks.

Public Communication and Outreach is an important activity towards dissemination of information on AERB's role, regulatory processes & functions and safety requirements to ensure that sources of ionizing radiations are handled, used and transported safely without causing harm to people and environment. In order to effectively interact with the different stakeholders (interested parties), AERB has in place a communication and outreach programme. The AERB policy on communication and stakeholder engagement draws from its Integrated Management System. The objective of such programmes is to a) disseminate effectively information on safety amongst interested parties and b) role of AERB in ensuring safe use of atomic energy and radiation applications.

Communication strategy of AERB

For gaining public trust, regulatory body needs to be taking decisions in an independent and objective manner without any external influence, as per the established norms. Such decisions should be predictable and consistent, without any biases. Further, competence of regulatory body is key to its credibility. Its staff should have necessary regulatory competencies to take ownership of the decisions. All the actions and decisions of a regulatory body needs to be taken in an open and transparent manner. The general public should know that regulatory body is not only capable of taking decisions but also should know how it has arrived at the decisions. This goes in a long way in building public confidence on regulatory actions, which should be taken without fear and favor in an honest and impartial manner. Last but not the least, regulatory body needs to continuously engage with interested parties (stakeholders) in a fair manner to obtain their views and feedback and should also let them know these have been considered in discharge of the regulatory functions.

These above elements are taken into consideration while developing the Communication strategy of AERB. As per this strategy, besides, keeping public and other interested parties informed about matters of safety significance through annual reports, newsletters, website updates, press releases etc., AERB has also initiated formal engagement mechanism with the stakeholders. While deciding the extent of engagement, the interest and influence levels of stakeholder groups are taken into consideration. This helps in prioritizing the stakeholders for strategizing the engagement methodology to ensure that their needs and expectations are recognized and understood.

AERB has taken efforts in this direction by developing in-house competency by undergoing training programme on Communication aspects from Indian Institute of Mass Communication, New Delhi.

Efforts for public information

AERB routinely provides information to public through annual reports, bulletins, newsletters and press releases. AERB also holds press conferences for communicating important milestones/information. AERB through its external website provides updates on its activities and information on radiation safety. In this line a lot of information has been placed in this website in the form of FAQs.

Apart from these traditionally available channels, AERB started conducting public outreach programmes for different segments of society. For stakeholders such as students, public intending to be benefitted from radiation applications, public residing in the vicinity of nuclear power plants, etc., AERB intends to continue and strengthen its public communication and outreach activities with an intent to educate and spread awareness on safety aspects and provide information about safety regulations. Towards this, AERB started participating in science festivals to spread awareness among students and science community. This had the dual benefit of reaching out to a large population of visitors and also get a first-hand understanding about their concerns. Based on feedback obtained from such interactions, AERB fine-tuned its outreach content, AERB has now prepared table-top models to evoke further interest by enhancing the visual appeal of concepts such as "Radiation hazard in the right Perspective" and "Emergency preparedness near Nuclear Power Plants". The programmes were unabated even during COVID, where many webinars reaching out to various sections of the society were carried out.

Left: AERB had set an exhibition stall at the Institute of Engineers (India) organised International Conference on Recent Developments in Clean and Safe Nuclear Power Generation (ICNPG)-2018. Honourable Shri Venkaiah Naidu, then Vice President of India inaugurated the exhibition. Right and below: AERB stalls

Awareness program to students near Kudankulam Nuclear Power Plant

Efforts towards stakeholder consultation

Conduct of NCRI:

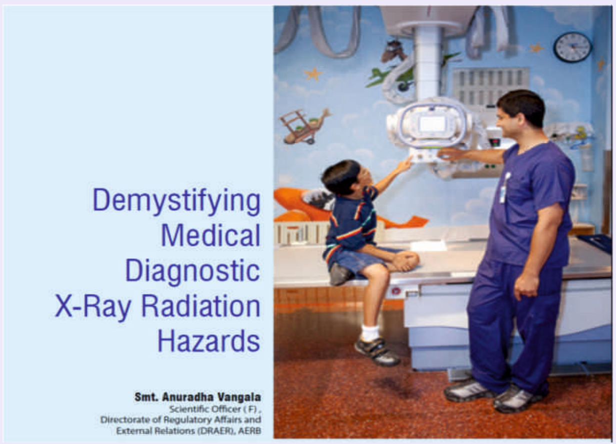
AERB started conducting the annual National Conference on Regulatory Interface (NCRI) since the year 2017, with an objective to foster an environment wherein, the Licensees, Stakeholders and Professional Associations could interact, discuss and provide valuable feedback to AERB on various issues related to Nuclear / Radiation Safety, regulatory requirements and practices world-wide, emerging trends in design and manufacturing, challenges in supply chain and other issues of regulatory interest.

Conduct of focused Stakeholder Programmes

AERB has a practice of obtaining public comments on its draft safety codes by uploading on its website. Recently, AERB started conducting focused stakeholder engagement programs by conducting physical meetings for obtaining feedback on regulatory documents being developed for practice specific radiation applications.

Interaction with Professional association: AERB routinely communicates and consults with professional associations to apprise them of the regulatory requirements and also take feedback on the recent advancements in applications of radiation. Few such professional associations with which AERB has been interacting are: Indian Radiological and Imaging Association, Nuclear Medicine Physicist Association of India, National Association for Application of Radioisotopes and Radiation in Industry (NAARRI), Society for Indian Radiographers (SIR), Indian Orthopedic Association (IOA), Indian Society for Vascular and Interventional Radiology (ISVIR), Indian Society for Radiographers and Technologists (ISRT) etc. AERB also participates in the

Continuous Medical Education programmes of hospitals as part of its safety awareness initiatives. Further, AERB routinely publishes articles in magazines and newsletters of professional bodies.



Left: Talk in IOA conference

Right: Article in ALARA Professional magazine

Nuclear Medicine Stakeholder consultation in progress

Efforts in training and awareness among first responders, media personnel

First responders: Realizing need for inculcating safety awareness among law and enforcement authorities regarding presence of high hazard radiation sources in their jurisdiction and also to be aware of the radiation hazard while acting as first responders, AERB proactively reached out these authorities to educate them on radiation safety and security aspects. AERB has carried out such programs in Gujarat, Rajasthan, Maharashtra, Andhra Pradesh etc;

AERB with the support of Office of Inspector General (Security), AP police organised a webinar in Telugu for the Police officials of AP. The theme of webinar was 'Security of Radioactive Sources'. Chairman AERB, Director General of Police, AP, IG (Security), DAE addressed on the occasion

Media

Media is a very important stakeholder for a regulatory body. AERB analyses media reports appearing in the day and reviews it for news relevant to AERB. This provides AERB an on-ground opinion of the public/ stakeholders towards not only atomic energy, but on regulatory decisions. To further enhance the connection and to make the media aware of AERB's role and regulatory processes, AERB conducted a workshop in its head office for Journalists from Mumbai region, including officials from Press Information Bureau. AERB also participated in the journalist workshops arranged by DAE at Kota and Kalpakkam to spread awareness on its regulatory activities.

Journalists meet at AERB

Safety promotion amongst Licensees

Safety Professionals Meet: Towards safety promotion amongst Licensees, AERB organizes theme meets, seminars, conferences. It also confers safety awards to the best performing units of DAE on safety front. AERB has also been organizing the annual DAE Safety and Occupational Health Professional Meet every year, which gives a platform to the safety and medical professionals from various DAE units to interact and share experiences with each other.

Awareness Tools (Audio-Visuals) - AERB developed short Video films on safety awareness of various practices to make the operators aware of the radiation safety requirements. These videos have been uploaded on social media platforms such as YouTube for wider and quick dissemination. Apart from this, leaflets and brochures were also developed and shared with the licensees for uploading on their websites and sharing with concerned staff. AERB provided Radio-Jingles and posted public notices and advertisements in newspapers, especially for low hazard Diagnostic X-ray facilities, to sensitize the users for complying with regulatory requirements.

Jaagrukta Seva Campaign: AERB also regulates low hazard activities such as Diagnostic X-ray facilities, which are very high in number. Lack of safety awareness was identified as one of the reasons for non-compliances observed in these facilities. AERB clubbed it inspection programme with awareness programmes named as "Jaagrukta Seva" campaigns to raise awareness about radiation safety.

Conclusion

AERB's structured stakeholder engagement programs has helped in enhancing trustworthiness and credibility of AERB. This assumes significance while dealing with crisis situations. In future, AERB is contemplating exploring emergent technologies, social media for maximizing the effectiveness of its communication and outreach programmes.

Role of Safety Research at AERB for Nuclear Regulation

Seik Mansoor Ali, H. Seshadri and D. K. Mohapatra
Safety Research Institute
Atomic Energy Regulatory Board
Kalpakkam – 603102, India

1. INTRODUCTION

The core functions of AERB are development of safety regulations, safety review & assessment, licensing, regulatory inspection & enforcement and monitoring of emergency preparedness & response. To have technical infrastructure and knowledge base, AERB had established the Safety Research Institute (SRI) in 1999 to develop research and development programme relevant to nuclear safety that would support its core regulatory functions. The following three objectives were set forth for SRI at the time of its inception.

- Carry out and promote nuclear safety research and analysis relevant to regulatory work
- Provide a forum for designers, operators, research groups and regulators to come together for formulation and implementation of research programmes aimed at resolving nuclear safety related issues
- Organize theme meetings, seminars and workshops on various topics of interest to AERB

Research areas undertaken at SRI are carefully chosen keeping in view their importance to safety assessment carried out at AERB as well as to complement the ongoing R&D work in other units of DAE. Ready availability of R&D infrastructure at IGCAR and recommendations from eminent experts of DAE fraternity were the guiding elements in the selection of work areas currently being pursued at SRI. To nurture the R&D temperament and culture and to gain insights into the contemporary safety issues, SRI sustains an in-house research programme commensurate with its resources. Analytical studies and development of computer codes are the focus areas since they do not require large infrastructure. SRI carries out independent scientific research in the field of Reactor & Radiation Physics, Reactor Thermal Hydraulics & Safety, Nuclear Chemistry and Environmental Impact Assessment. An overview of research activities to support the regulatory decision-making process by AERB are delineated in the subsequent sections.

2. REACTOR AND RADIATION PHYSICS

It is envisaged that India would expand its nuclear power programme by deployment of advanced and new generation nuclear power plants (NPP) in association with integral fuel cycle facilities. To support effective regulation of these new NPP systems and facilities, utmost importance has been given to develop technical expertise in the areas of Reactor and Radiation Physics. Towards this, SRI has appropriately selected research topics in the areas related to advanced thermal reactors, fast breeder reactors, nuclear fuel cycle and radiation safety associated with these systems.

2.1 Thermal Reactor Physics

In addition to the indigenous three stage nuclear power program, advanced light water reactors (LWRs) of higher power are being commissioned in India to meet the growing energy demand. As an initiative, two units of Russian designed pressurized water type VVER-1000 reactors are operational at Kudankulam, Tamil Nadu and four more units of similar type are under construction. As a part of independent verification and research, extensive reactor physics calculations are carried out in-house towards safety review of the VVER-1000 reactors. The studies include, independent verification analysis of commissioning experiments, viz., first approach to criticality, low and high-power physics experiments, fuel safety evaluation review for each refueling cycle, reactivity initiated transient analysis etc. Further, towards the indigenously designed Pressurized Heavy Water Reactor (PHWR) of higher power rating (700 MWe), which has been evolved from the 540 MWe design with notable differences and first of a kind feature, independent verification of the safety aspects and related design documents have been carried out to support regulatory decision-making process by ensuring that the reactor physics parameters are within the stipulated safety criteria. Additionally, in recent years the thermal reactor analysis has been extended to the advanced LWR systems (EPR-1650, AP-1000, VVER-1200 etc.) with improved passive safety features that claim to meet Generation III+ category.

2.2 Fast Reactor Physics

Fast reactor physics studies are aimed towards the safety review of the Fast Breeder Test Reactor (FBTR) operational at Kalpakkam, the Prototype Fast Breeder Reactor (PFBR) which is in advanced stage of commissioning and future advanced fast reactor designs. Owing to the significance of PFBR (sodium cooled, mixed oxide fuelled pool type reactor of 500 MWe power) being the first of a kind reactor designed indigenously in the country, keen interest has been taken in the evaluation of its reactor physics aspects in order to support the regulatory decision making. Additionally, the metal fuel cycle, which offers higher breeding gain and lower fuel doubling time in fast breeder reactors (FBRs), is considered for thorough investigations. Several futuristic metal-fuelled FBR designs with Uranium-Plutonium-Zirconium ternary alloy fuel have been analyzed to evaluate their safety parameters and breeding behavior vis-à-vis conventional MOX fuelled fast reactors. Furthermore, in order to analyse the dynamic behaviour of FBRs and establish their stability range under different reactivity insertion conditions, attempts are made to develop indigenous computational tools in modern software environment for studying the following viz., transient over power events, loss of flow and loss of heat sink conditions that lead to unsafe reactor states, characterization of stable dynamic regimes and core disruptive accident (CDA) conditions etc.

2.3 Radiation Safety

A well-equipped radiation physics laboratory has been established at SRI to carry out radiation shielding and environmental radioactivity related experiments. The objective of the laboratory is to carry out experiments for validation of computer codes and computational methods adopted in radiation transport studies. Few important radiation safety studies include, experiments to quantify radiation streaming through inhomogeneities in bulk shield structures, prediction of neutron beam attenuation in mild steel, boron carbide, ferro-boron etc., investigation of attenuation characteristics of advanced gamma and neutron shield materials, characterization of work place materials for retrospective dosimetry, environmental radioactivity analysis etc.

3. REACTOR THERMAL HYDARULICS AND SAFETY

Reactor safety is of paramount importance to AERB and SRI contributes in several areas that include nuclear reactor thermal hydraulics, fire safety, hydrogen mitigation, severe accident analysis, safety aspects of nuclear systems and components etc. A brief description of experimental facilities and analytical research works to support regulatory decision-making are highlighted below.

3.1 Core Melt Retention Facility (COMREF)

Studies on in-vessel corium retention capability of calandria vessel of Indian PHWRs during postulated severe accident conditions has been one of the focus areas in recent years. COMREF was setup at SRI for this purpose (Fig.1a). A scaled-down test vessel having curvature same as the prototype 700 MWe PHWR calandria, submerged in a water tank represents the calandria vessel and vault assembly. High frequency eddy current developed by an induction heating machine is used to simulate the decay heat flux on the vessel inner surface. The facility is well instrumented for measuring temperatures at critical locations. Several experiments have been carried out to ascertain the possibility of departure from nucleate boiling (DNB) or film boiling on the outer surface of the test vessel. Saturated and sub-cooled boiling conditions have been created by varying the heat flux and the effect of subcooling of vault water, presence of flow obstructions etc. on DNB have been investigated. A comprehensive hydrodynamics model based on two-phase boundary layer flow has also been developed and validated to predict the critical heat flux (CHF) on the outer surface of calandria vessel. These studies have contributed immensely to the regulatory review of severe accident management in Indian PHWRs.

3.2 Water and Steam Interaction Facility (WASIF)

WASIF has been commissioned at SRI in collaboration with Reactor Safety Division (RSD) of BARC to investigate various forms of Direct Contact Condensation (DCC) that have a direct bearing on safety of reactor systems and components (Fig.1b). Phenomena such as Condensation Induced Water Hammer (CIWH) in horizontal pipe, sub-cooled water injection into flowing steam, interaction of water droplets with steam in enclosed space, steam injection into stagnant and sub-cooled water etc. can be studied. The facility is built in two phases; in Phase-1, experiments on CIWH are undertaken and in Phase-2, suppression pool hydrodynamics and efficacy of containment sprays are investigated. The data from these experiments are used for validating the existing and newly developed numerical models. One of the main outcomes of this experimental program is the improvement in understanding of DCC related safety issues and their possible implications on safety.

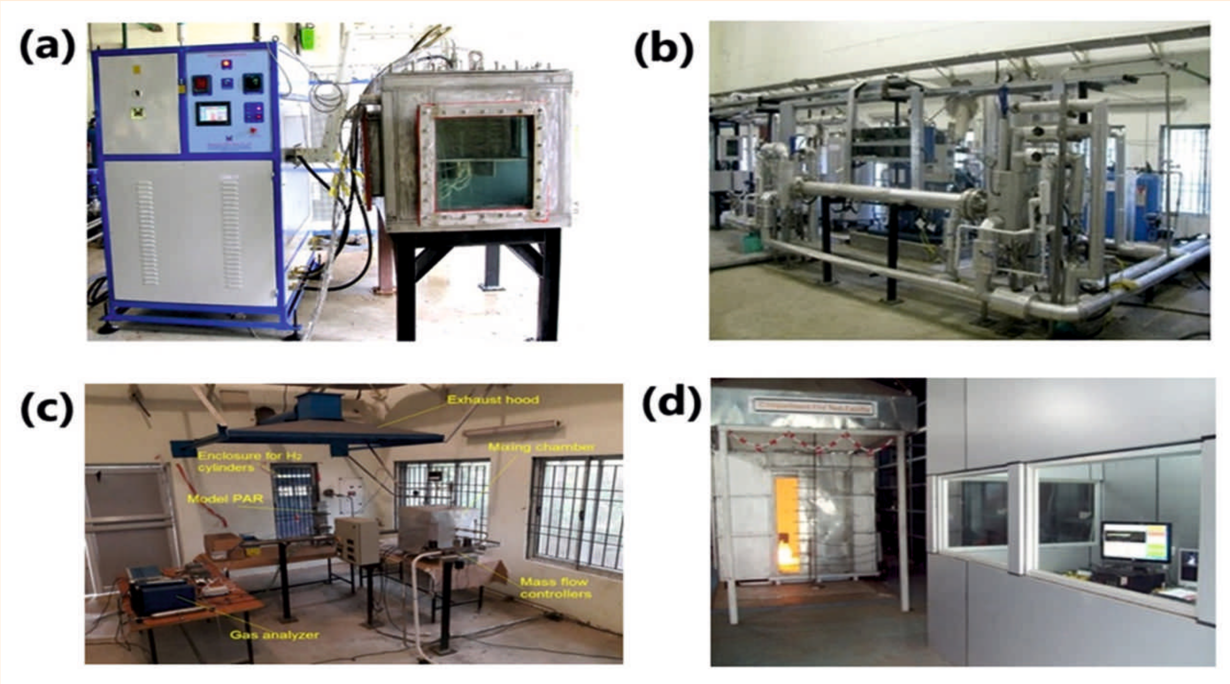


Fig.1. Experimental facilities at SRI for thermal hydraulic safety studies; (a) COMREF, (b) WASIF, (c) HYMIF, (d) CFTF

3.3 Hydrogen Mitigation Facility (HYMIF)

Passive removal of hydrogen generated following a severe accident scenario is essential for preventing the formation of an explosive mixture that can challenge the integrity of the reactor containment. The Hydrogen Mitigation Facility (HYMIF) has been setup to study the performance aspects of Passive Autocatalytic Recombiner Device (PCRD) under simulated accident conditions (Fig.1c). Catalyst coupons developed by BARC and IGCAR have been tested in this facility to determine the catalyst plate temperature and hydrogen removal efficacy. In-house CFD tools have also been developed, validated and applied for hydrogen mitigation studies. These studies have provided valuable inputs for regulatory review of hydrogen safety and also contributed to forming of new regulatory guidelines on hydrogen mitigation.

3.4 Compartment Fire Test Facility (CFTF)

A Compartment Fire Test Facility (CFTF) is setup at SRI for the purpose of investigating hydrocarbon pool fires and cable fires within enclosures (Fig.1d). The facility is also used for testing the fire resistance rating of barriers. Pool fires are conducted to understand the burning behaviour of combustibles and solvents that are used in the nuclear industry. The effect of fuel quantity, type, ventilation opening area etc. on the enclosure fire development is studied. Confirmatory fire tests on un-coated and intumescent paint coated power and control cables used in NPPs are carried out in this facility. Several samples of XLPE and FRLS PVC cables have been tested in horizontal and vertical-tray flame test configurations to understand the flame spread characteristics. The effect of hydrocarbon/oil spill fire on power and instrumentation cables have also been investigated. Recently, tests on samples of fire barriers used in critical areas of NPPs were conducted to obtain an estimate of their fire resistance rating. Apart from experiments, fire modeling using CFD tools is also an important part of the R&D work. These studies have been utilized by the utilities as well as AERB for review purpose.

4. NUCLEAR CHEMISTRY AND ENVIRONMENTAL SAFETY STUDIES

The prime objective of the chemistry and the environmental safety programme at SRI is aimed towards supporting the safety objectives of AERB pertaining to reactor chemistry, fuel cycle processes, environmental impact assessment etc. Some of the important contributions in these areas are highlighted below:

4.1 Experimental facility to study the corrosion aspects of Zr-2.5%Nb

Extensive studies have been taken up on the corrosion behavior of Zr-2.5%Nb that is used as the PHWR pressure tube material. Towards this, a corrosion test facility was set up (Fig.2), which has the flexibility for operating in either purge or recirculatory mode, spiking the desired quantity of impurity required for the study, varying the experimental parameters such as flow, temperature etc.

4.2 Experimental facility to study iodine behavior in reactor containment

Assessment of a range of nuclear accident scenarios indicate that the fission product iodine contributes significantly to the radioactive source term. With new and novel reactor designs, the chemical forms of iodine in reactor containment is of contemporary importance. Therefore, 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. Towards this, a bench scale iodine experimental facility has been established at SRI (Fig.3). The facility has been so designed that it has the flexibility to independently study the gaseous phase, aqueous phase and the combination of both phases.

4.3 Phytoremediation of radioactively contaminated geo-environment

It is well known that radionuclides enter the soil and water through human activities such as mining and milling of nuclear fuel, fallout from nuclear weapon testing and occasional nuclear accidents. Contamination of soil with ^{137}Cs and ^{90}Sr has long term radiological and health impacts due to their long half-lives and chemical similarities with two essential elements required for plant growth, Ca^{2+} and K^{+} respectively. Out of the various remediation techniques, Phytoremediation i.e., the use of plants for remediation of soil and water contaminated with low level of toxic metals and radionuclides has received a lot of attention in the past few years due to its environment friendly and easily affordable nature. Towards this, systematic study has been undertaken for the remediation of Cs and Sr from the soil using phytoremediation techniques. Based on the efficacy towards the uptake of non-radioactive Cs and Sr, few hyper-accumulating plant species were identified and subjected to hydroponic studies. The plants were further taken for pot culture experiments to observe their hyper accumulating ability from the soil. It is found that the selected species are able to uptake Cs and Sr effectively without showing much of effect on plant physiology. Further, the plant species are found to be stable in a radioactive environment and hence suitable for remediation of radioactively contaminated environment.

Fig.2 Facility for corrosion studies

Fig.3 Facility for Iodine behaviour studies

4.4 Atmospheric dispersion modelling and radiological impact assessment

In the very unlikely event of a severe accident at any NPP, reactor containment may breach leading to release of radionuclides to the environment. The cumulative radioactivity release depends on the severity of the accident. Once released to the environment, radionuclides will get dispersed horizontally and vertically by the turbulent eddies present in the atmosphere. Meteorological conditions around the NPP site largely determine the affected sectors and the radiation levels. Based on the radiation levels, various counter measures such as sheltering, evacuation, and distribution of iodine prophylaxis are taken to avert deterministic effects and to reduce the chances of stochastic effects. This necessitates detailed modelling of the dispersion of radioactivity in the atmospheric that includes site specific characteristics and subsequent radiological impact assessment. Towards this, SRI has established the necessary computational infrastructure and knowledgebase for undertaking coupled numerical weather forecasting and atmospheric dispersion modelling to support the nuclear and radiological emergency monitoring at AERB.

4.5 Remote sensing and geographical information systems application studies

Remote sensing technology is one of the best-suited means for the assessment of environmental impacts posed by the industrial establishments, energy sector including nuclear installations all over the world. With the availability of multi sensor and multi temporal data, utilization of Remote Sensing and Geographic Information System (RS-GIS) in different sectors is increasing day by day. The RS-GIS technology provides immense scope to plan for environmental monitoring and mitigation measures around nuclear power plant sites. The applications of RS-GIS range from environmental impact assessment to emergency response planning, landfill monitoring, natural disaster mitigation etc. The broad applications of this technology are indicated in Fig.4. In view of this, a RS-GIS facility has been set up at SRI with the objective to develop geo-technical data base and information system around the NPP sites in the country as a reference for site evaluation, monitoring of the environmental impacts and management of emergency situations.

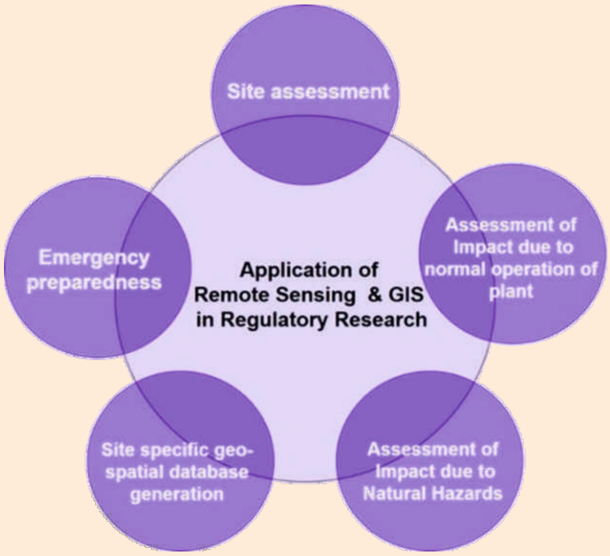


Fig.4 Application of RS-GIS technology

5. RESHAPING THE FUTURE SAFTY RESEARCH: *An outcome of Manthan*

Soon after taking over the Chairmanship of AERB, Shri D. K. Shukla initiated a series of brainstorming sessions across its various divisions called the *Manthan* series, that served as a platform for retrospection and introspection, marking the 40th anniversary of AERB. The aim of the series was to pave the way for the future functioning of AERB and reinforce its mission and vision. This period has been perceived as the *Sankranti Kaal*, a time of transformation that marks a strategic turning point, prompting all divisions, including the Safety Research Institute, to rethink and reinforce their contributions to nuclear safety and regulation.

At SRI, Kalpakkam, a series of *Manthan* discussions were held to reassess and refine the strategic approach for future research, particularly concerning nuclear safety. In June 2024, a Theme Meeting titled “Role of Safety Research in Nuclear Regulation: Current Status and Future Directions” was organized at SRI to focus on the evolving landscape of safety research within DAE units, utilities, AERB, and academia. This event served as a pivotal forum for evaluating the status of safety research and addressing how emerging technologies in the nuclear sector could be integrated into the regulatory framework.

The key outcomes of the *Manthan* deliberations led to the following strategies for the overall safety research programme of AERB:

1. Collaborative and dynamic research approach: While SRI possesses limited independent infrastructure, it can effectively tap into the extensive resources available within DAE, national research institutions, and academic organizations. A coordinated and dynamic approach, leveraging these external facilities, is essential for advancing nuclear safety research.

2. *Objective-driven research with defined priorities:* Research must be conducted with clear objectives and systematic planning. SRI, rather than duplicating efforts of Technical Support Organizations (TSOs) or academic institutions, should focus on facilitating access to external expertise, ensuring that research is targeted at priority areas aligned with regulatory needs.

3. *Strengthening in-house research:* SRI will continue to cultivate its in-house research capabilities. This will not only sustain its expertise, but also provide critical insights into contemporary safety issues. However, the focus will remain on collaboration and coordination rather than expansion into areas already covered by other institutions.

4. *Formation of the Advisory Committee for Safety Research (ACSR)*: In a strategic move to bolster research efforts, an Advisory Committee for Safety Research (ACSR) was constituted under the aegis of AERB to provide expert advice and recommendations on safety research matters. The ACSR will play a crucial role in identifying priority research areas, integrating national research programmes, and ensuring that India's nuclear safety research aligns with global standards. SRI under the guidance of ACSR, will act as a nodal agency for executing large-scale projects, harnessing the expertise of external institutions to meet the research needs of AERB.

In a nutshell, the *Manthan* series has provided a critical platform for shaping the future strategies and direction for AERB's research efforts. Enhancing the safety research programme of AERB through a structured approach represents a strategic imperative to fortify the foundation of nuclear safety, foster innovation and uphold public trust. By focusing on collaboration, prioritizing objectives, and enhancing SRI's role in coordinating national safety research initiatives, AERB is poised to lead the way in ensuring nuclear safety and regulatory excellence.

CONCLUSION

A brief overview of the independent safety research and analysis activities carried out at the Safety Research Institute of AERB have been presented. The R&D activities as highlighted in the article cover the contributions in wide range of nuclear safety related topics that include but not limited to reactor and radiation physics, reactor thermal hydraulics and safety, nuclear chemistry and environmental impact assessment. These research topics have a bearing on the protection of public and environment from undue risks of radiation. The independent safety research programme established by AERB has strengthened the regulatory review and decision-making process based on credible information and technically sound judgment. Further, based on the outcomes of the recent *Manthan* within AERB for reshaping of future safety research programs, AERB is poised to take up the safety review and regulatory evaluations of new and emerging nuclear technologies and facilities in India.

IAEA reviews the Regulatory Infrastructure of India for Nuclear and Radiation Safety

Initial International Atomic Energy Agency (IAEA) Integrated Regulatory Review Service (IRRS) Mission to India was held during March 16-27, 2015. The scope of this mission was limited to nuclear power plants (NPPs). At the request of the Government of India, IAEA organized an IRRS Extended Follow up Mission as part of the 1st IRRS India cycle. Mission took place from 9 to 20 June 2022 to review the national regulatory infrastructure against the IAEA safety standards.

The June 2022 Mission consisting of an international team of senior safety experts, reviewed India's progress against the recommendations and suggestions identified in the initial IRRS mission - 2015 and the review also included radiation sources facilities and activities.

The IAEA coordinated IRRS Extended follow up mission was led by Mr. Ramzi Jammal, Executive Vice-President and Chief Regulatory Officer of the Canadian Nuclear Safety Commission (CNSC). The ten member IRRS team comprised of senior regulatory experts from five IAEA Member States and the IAEA staff members.

The peer review was undertaken by comparison of existing arrangements against IAEA safety standards and the Code of Conduct on safety and security of radioactive sources as the international benchmark for safety. The Mission was preceded by a detailed self-assessment exercise carried out by AERB. The Mission provided AERB with an opportunity for exchange of information with international regulatory experts and to further enhance the regulatory framework and processes in India.

A preparatory virtual meeting for the mission was organized virtually from 21 to 23 July 2020 with AERB to discuss the purpose, objectives, scope and detailed preparations of the review. It was agreed that the review will be extended to include radiation sources facilities and activities which was not part of the initial mission.

In preparation for the IRRS extended follow up mission, AERB carried out self-assessment for this extended IRRS follow-up mission, considering the progress made in relation to the recommendations and suggestions given during initial IRRS mission and using Self-Assessment of Regulatory Infrastructure for Safety (SARIS) web based tool developed by IAEA for Self-assessment for the extended topic "Radiation Sources Facilities and Activities" with respect to IAEA safety standards.

The self-assessment included identification of gap areas / areas for improvement / action plan. As part of preparation of Advance Reference Materials (ARMs), for submission to IAEA as per IRRS process, Summary Report, Answers to SARIS questionnaires and its analysis were prepared and relevant evidences were identified for submission to IAEA.

To carry out an assessment by an independent team, IRRS Preparedness Assessment Team (IRRS-PAT), was constituted by AERB. The ARMs were provided to IRRS-PAT for their independent assessment. Based on the observations made by IRRS-PAT, these ARMs were updated, reviewed and finalized. The finalized ARMs were uploaded in IAEA portal on April 07, 2022.

The mission included interviews and discussions with AERB staff, including the provisions of new evidences as requested by the IRRS team. In addition, two policy issues were discussed in the course of the mission in order to share experiences on:

- Safe management of Disused Sealed Radioactive Sources (DSRS); and
- Regulation of radioactive waste from radiation facilities handling unsealed sources.

The mission commenced with entry meetings of IRRS team with the officials of AERB, and Department of Atomic Energy (DAE) on June 09 and June 14, 2022. The Mission performed a systematic review of all topics by reviewing the Advance Reference Materials, additional information provided, and by conducting interviews with staff and management of AERB, as well as direct observations of regulatory oversight activities of use of the radiation sources. Two IRRS team Members witnessed AERB's regulatory inspection activities at Radiation Processing Plant, Board of Radiation & Isotope Technology (BRIT) to evaluate the inspection practices of AERB.

The IRRS team recognized the systematic approach to integrate the approval of equipment with the need for a consent to an applicant prior to procuring a radiation source and the issuance of a consent to operate a facility or conduct an activity with radiation sources, as a Good Performance.

The IRRS team acknowledged that AERB has further increased its participation in the Global Nuclear Safety Regime and the IRRS team encouraged the Government of India to ensure AERB has sufficient resources for continued international engagement on the development of safety standards and the exchange of information on nuclear and radiation safety.

The IRRS team also acknowledged that the AERB has considered the recommendations and suggestions made during the 2015 mission and improvements have been made in various areas. The IRRS team after review accepted that satisfactory progress has been carried out with respect to the earlier recommendations/suggestions and out of the original 13 recommendations and 21 suggestions, 11 recommendations and 20 suggestions were closed and the IRRS team did not make any new finding in relation to the topics covered during the IRRS initial mission w.r.t. radiation sources, the team also concluded that the AERB properly implements radiation safety requirements in India in accordance with IAEA regulations. Some areas for improvement were also identified and the IRRS team made 3 recommendations and 3 suggestions.

The IRRS team identified a Good Practice in relation to the integration of regulatory processes within e-LORA, an online platform used by the applicants, authorized parties and AERB. e-LORA platform has significantly improved in efficiently managing the information to be submitted by an applicant / authorized party, based on a graded approach.

The team acknowledged that since 2015, the AERB has made a number of achievements in the following areas:

- ✓ improved inspection programme, including enhanced training and strengthening the powers of inspectors;

- ✓ staff qualification and training programmes aimed at building and maintaining expertise necessary for discharging its responsibilities;
- ✓ Process for regularly reviewing regulations and guides.

In the area of radiation sources facilities and activities, the IRRS team identified three recommendations and three suggestion.

- ✓ Safety assessments which have to be part of the application for a consent in a systematic manner;
- ✓ Submission of independent verifications of the safety assessments of radiation sources facilities and activities when appropriate in accordance with a graded approach;
- ✓ Establishment of comprehensive radiation protection programmes for all facilities and activities;
- ✓ Revision of the frequency of planned inspections and the duration of validity of regulatory consent in accordance with a graded approach;
- ✓ Development of a national policy and strategy to define responsibilities in regaining control over orphan sources; and
- ✓ Revision of regulations and guides, where appropriate, to ensure consistency with the IAEA safety standards and clarification of the hierarchy of the regulatory documents.

Some of these recommendations / suggestions relate to formalizing the practices into formal written down procedures and to strengthen internal management processes. AERB has accepted these as an opportunity to further improve the regulatory framework. The full report of IRRS India Mission is available on website link https://www.iaea.org/node/67197

YOUNG NUCLEAR PROFESSIONAL FORUM

SUMMARY REPORT OF THE LECTURE ORGANIZED BY INDIAN NUCLEAR SOCIETY ON " NUCLEAR FUEL CYCLE AND ADVANCED FUEL "

Indian Nuclear society (INS) had organized the lecture on "Nuclear Fuel Cycle and Advanced Fuels" under the theme of "INS - Young Nuclear Professional forum" on Friday 25th October 2024 at INS office Lecture Hall, Project Square, Anushaktinagar, Mumbai.

The intention of the talk was to create awareness among young engineers of DAE about latest updates on advanced fuels.

In view of this, Expert speaker Shri Rahul Tripathi, ACE (FCM), NPCIL, was invited to deliver the talk.

About 40 engineers from various units of DAE and AERB attended the lecture. INS Vice- President Shri Satyawan Bansal and Treasurer, Shri O.P. Rai welcomed the expert speaker and the participants.

Dr. Nitin S More, Course coordinator and Executive Committee Member, INS highlighted the initiative of "INS - Young Nuclear Professional Forum" to benefit young engineers of DAE through series of lectures on essential topics based on current scenarios.

Shri Rahul Tripathi delivered a presentation on Nuclear Fuel Cycles adopted in India and worldwide. He explained the manufacturing cycle of natural U-fuel and fuels used in different reactors, He stressed the importance of advanced fuels considering demand in future and briefed about the latest developments in advanced fuels.

Shri K.T.P. Balakrishnan honoured the speaker on behalf of INS, and Dr. Nitin S More expressed vote of thanks.

Indian Nuclear Society

Indian Nuclear Society's Annual Conference

INSAC-2024

Regulatory Framework for Nuclear Renaissance

November 19-21, 2024

DAE Convention Centre, Anushaktinagar, Mumbai - 400094

About the Conference

Nuclear power is witnessing resurgence in recent years and now viewed as an inevitable solution to address the global energy needs with net-zero emissions. At the COP28 meeting (Conference of Parties) held in December 2023 in the UAE, all participating nations pledged to work towards clean energy sources, including nuclear power. This upcoming nuclear renaissance has several dimensions, such as the deployment of advanced nuclear reactors like Fast Breeder Reactors (FBR), Small Modular Reactors (SMR), Molten Salt Breeder Reactors (MSBR), and Compact High-Temperature Reactors (CHTR). Additionally, several countries have realized the potential of nuclear power for generating green hydrogen as a carrier of energy. Furthermore, innovative application of radiation and radioactive sources has seen significant growth in India's medical and industrial sectors.

To realize the full potential of nuclear energy, concerted efforts are required to likewise develop regulations and deploy regulatory practices that ensure the highest safety standards. Realizing the critical importance of a robust nuclear regulatory framework for the safe and swift expansion of nuclear and its applications, the Indian Nuclear Society (INS) announces its Annual Conference on "Regulatory Framework for Nuclear Renaissance". This conference, organized in association with the Atomic Energy Regulatory Board (AERB) of India, will feature expert talks, panel discussions, and contributory papers.

Web. : www.insac2024.org | Email : insac2024@gmail.com

Conference Topics

- Regulatory framework for nuclear safety
- Challenges in safety review of 3-stage Indian nuclear program
- Experiences in safety review & licensing of 700 MWe PHWRs
- Graded approach in regulation of nuclear & radiation safety
- Challenges in regulating speedy deployment of nuclear energy
- Development of regulatory framework for new and emerging technologies
- Regulatory framework: Preparing for new entrants
- Safety and security interface challenges
- Regulator's role in building public trust and encouraging industry excellence
- Development of regulations and stakeholder participation
- Emergency preparedness and response: Requirement and planning for assurance of public safety (roles & responsibilities)
- Global initiatives on radiation safety in healthcare infrastructure
- Preventing unintended exposure, strengthening radiation safety culture and promote reporting and learning system
- Radiological safety preparedness in food processing industries
- Safety challenges in rapid growth of radiation applications in medical and industrial areas
- Safety research for regulatory decision making
- Regulatory oversight during manufacturing stage of the Nuclear installations
- Global synergy for enhanced nuclear safety and security in the nuclear renaissance
- Strengthening resources and expertise in regulatory body
- Leadership and management for safety