सत्यमेव जयते

Government of India

NATIONAL REPORT

to

THE CONVENTION ON NUCLEAR SAFETY

Seventh Review Meeting of Contracting Parties, March 2017

August 2016

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Foreword

The Government of India ratified the Convention on Nuclear Safety on March 31, 2005. India started presenting its national reports from the 4th Review Meeting of the Contracting Parties of the CNS in 2008. The present national report for the 7th Review Meeting is the fourth one being submitted by India. The Report updates how Government of India continues to fulfill its obligations under Articles 6 through 19 of the Convention.

The National Report was prepared in line with the guidelines contained in information circular INFCIRC/572/Rev.5 on “Guidelines regarding National Reports under the Convention on Nuclear Safety”, the summary report of the 6th Review Meeting, additional recommendations for the preparation of national reports for the 7th Review Meeting dated October 8, 2015, and the letter written by President of 7th Review Meeting of CNS to the Contracting Parties in February 2016. All land-based nuclear power plants including storage, handling and treatment facilities for radioactive materials attached to the NPP and directly related to the operation of nuclear power plants are covered in the national report.

This report also addresses the national position with regard to the Vienna Declaration on Nuclear Safety for the implementation of the objectives of the CNS.

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List of Acronyms

ACIFS	Advisory Committee for Industrial and Fire Safety
ACOH	Advisory Committee on Occupational Health
ACPSR	Advisory Committee for Project Safety Review
ACNS	Advisory Committee on Nuclear Safety
ACROSS	Apex Committee for Review of Operating Station Safety
AC-RSR	Advisory Committee for Review of Safety Research
ACRS	Advisory Committee on Radiological Safety
ACS	Advisory Committee for Security
AEC	Atomic Energy Commission
AERB	Atomic Energy Regulatory Board
AERBSC-EE	AERB Safety Committee for External Events
AHWR	Advanced Heavy Water Reactor
AGFS	AERB Graduate Fellowship Scheme
AGMS	Annulus Gas Monitoring System
AHWR	Advanced Heavy Water Reactor
ALARA	As Low As Reasonably Achievable
AMD	Atomic Minerals Directorate for Exploration and Research
AMG	Accident Management Guidelines
AOO	Anticipated Operational Occurrence
BARC	Bhabha Atomic Research Centre
BARCIS	BARC Channel Inspection System
BHAVINI	Bharatiya Nabhikiya Vidyut Nigam Limited
BRIT	Board of Radiation & Isotope Technology
BRNS	Board of Research in Nuclear Sciences
BSD	Biennial Shutdown
BWR	Boiling Water Reactor
CCC	Construction Completion Certificate
CEA	Central Electricity Authority
CESC	Civil Engineering Safety Committee
CFVS	Containment Filtered Venting System
CMG	Crisis Management Group
COG	CANDU Owners Group
CPR	Corporate Peer Review
CSIR	Council for Scientific & Industrial Research
CSNI	Committee on Safety of Nuclear Installations
CSRP	Committee for Safety Research Projects
DAE	Department of Atomic Energy
DEC	Design Extension Conditions
DDMA	District Disaster Management Authority
DG	Diesel Generator
DIL	Derived Intervention Levels
DRD	Direct Reading Dosimeter
DSS	Decision Support System
EAC	Expert Appraisal Committee
EAL	Emergency Action Levels
EMCCR	En-Masse Coolant Channel Replacement
ECC	Emergency Control Centre
ECR	Emergency Communication Room
ECCS	Emergency Core Cooling System
ECNR	Event Closing Notification Report
EDG	Emergency Diesel Generator
EIA	Environment Impact Assessment
EOP	Emergency Operating Procedure

EPA	Early Protective Actions
EPD	Extended Planning Distance
EPR	Emergency Preparedness and Response
EPZ	Emergency Planning Zone
ERRC	Eastern Regional Regulatory Centre
ESL	Environmental Survey Laboratory
FAC	Flow Assisted Corrosion
FBR	Fast Breeder Reactor
FHS	Fuel Handling System
FOAK	First of a kind
FPC	First Pour of Concrete
FSAR	Final Safety Analysis Report
GC	Generic Criteria
GDF	Geological Disposal Facility
GSR	General Statutory Rules
HBNI	Homi Bhabha National Institute
HLLW	High Level Liquid Waste
HPU	Health Physics Unit
HQ	Head Quarter
HQI	Head Quarter Instruction
HRTF	Hydrogen Recombiner Test Facility
HWB	Heavy Water Board
IAEA	International Atomic Energy Agency
IERMON	Indian Environmental Radiation Monitoring Network
ICPD	Ingestion and Commodities Planning Distance
ICRP	International Commission on Radiation Protection
IGCAR	Indira Gandhi Centre for Atomic Research
IIT	Indian Institute of Technology
IMS	Integrated Management System
INES	International Nuclear and Radiological Event Scale
IPR	Institute for Plasma Research
IPSD	Industrial Plants Safety Division
IPWR	Indian Pressurised Water Reactor
IREL	Indian Rare Earths Limited
IRRS	Integrated Regulatory Review Services
IRS	Incident Reporting System
ISI	In-service Inspection
KAPS	Kakrapar Atomic Power Station
KGS	Kaiga Generating Station
KKNPP	Kudankulam Nuclear Power Plant
LCO	Limiting Conditions for Operation
LOCA	Loss of Coolant Accident
LSSS	Limiting Safety System Settings
LWR	Light Water Reactor
MAPS	Madras Atomic Power Station
MDEP	Multinational Design Evaluation Programme
MoEFCC	Ministry of Environment, Forests and Climate Change
MOX	Mixed oxide
NAPS	Narora Atomic Power Station
NBHM	National Board for Higher Mathematics
NCMC	National Crisis Management Committee
NDMA	National Disaster Management Authority
NDRF	National Disaster Response Force
NEA	Nuclear Energy Agency
NEC	National Executive Committee
NFC	Nuclear Fuel Complex
NODRS	National Occupational Dose Registry System

NPCIL	Nuclear Power Corporation of India Limited
NPC-SRC	NPCIL Safety Review Committee
NPP	Nuclear Power Plant
NPSD	Nuclear Projects Safety Division
NREMC	Nuclear and Radiological Emergency Monitoring Cell
NRRC	Northern Regional Regulatory Centre
NSAD	Nuclear Safety Analysis Division
NSDF	Near Surface Disposal Facility
NSRA	Nuclear Safety Regulatory Authority
NTC	Nuclear Training Centre
OE	Operating Experience
OED	Off-site Emergency Director
OERC	Operating Experience Review Committee
OERG	Operating Experience Review Group
OESC	On-site Emergency Support Centre
ONERS	Online Nuclear Emergency Response Decision Support system
OIL	Operational Intervention Level
O&M	Operations & Maintenance
OPSD	Operating Plants Safety Division
OSART	Operational Safety Review Team
PAZ	Precautionary Action Zone
PCB	Pollution Control Board
PCRD	Passive Catalytic Recombiner Device
PDHRS	Passive Decay Heat Removal System
PDSC	Project Design Safety Committee
PFBR	Prototype Fast Breeder Reactor
PHT	Primary Heat Transport
PHWR	Pressurised Heavy Water Reactor
PIE	Postulated Initiating Events
PSA	Probabilistic Safety Assessment
PSAR	Preliminary Safety Analysis Report
PSR	Periodic Safety Review
PUA	Precautionary Urgent Protective Actions
QA	Quality Assurance
QC	Quality Control
QMS	Quality Management System
RAPS	Rajasthan Atomic Power Station
RCA	Root Cause Analysis
R&DD	Resources and Documentation Division
RO	Responsible Organisation
RPR	Radiation Protection Rules
RPV	Reactor Pressure Vessel
RRCAT	Raja Ramanna Centre for Advanced Technology
RSD	Radiological Safety Division
RSO	Radiological Safety Officer
RSZ	Radiological Surveillance Zone
SAM	Severe Accident Management
RTI	Right To Information
SARCAR	Safety Review Committee for Application of Radiation
SARCOP	Safety Review Committee for Operating Plants
SBO	Station Black Out
SCR	Supplementary Control Room
SDDP	Safety Document Development Proposal
SDMA	State Disaster Management Authority
SDS	Shutdown System
SEC	Site Evaluation Committee
SECC	Site Emergency Control Centre

SED	Site Emergency Director
SER	Significant Event Report
SERC	Site Emergency Response Committee
SFTD	Spent Fuel Transfer Duct
SG	Steam Generator
SINP	Saha Institute of Nuclear Physics
SNRIU	State Nuclear Regulatory Inspectorate of Ukraine
SORC	Station Operation Review Committee
SPND	Self-Powered Neutron Detector
SRI	Safety Research Institute
SSC	Structures, Systems and Components
SSED	Siting and Structural Engineering Division
SSSC	Standing Site Selection Committee
STAR	Stop Think Act Review
STD	System Transfer Document
TAPS	Tarapur Atomic Power Station
TIFR	Tata Institute of Fundamental Research
TLD	Thermo Luminescence Dosimeter
TSO	Technical Support Organisation
UCIL	Uranium Corporation of India Limited
UPZ	Urgent Protective Action Planning Zone
USC	Unit Safety Committee
USNRC	United States Nuclear Regulatory Commission
UPA	Urgent Protective Actions
VECC	Variable Energy Cyclotron Centre
WANO	World Association of Nuclear Operators

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INTRODUCTION

1.0 GENERAL

India considers the role of nuclear power as vital for long term energy security and sustainable development of the country. To increase the nuclear power capacity in the country, India pursues development and deployment of nuclear power plants through indigenous technologies as well as import of reactors from abroad. India is pursuing comprehensive programmes in radiation and isotope technologies for societal benefit in the areas of food preservation, development of superior mutant varieties of seed/crops, nuclear medicine for diagnostics and radiation therapy, industrial radiography, sewage and waste management etc. These programmes have been making significant contributions to India's development.

Nuclear facilities in India are sited, designed, constructed, commissioned and operated in accordance with strict quality and safety standards. The primary responsibility for the safety of the facility lies with the licensee. These licensees have a system of independent review and scrutiny of safety as an integral part of the management control. Atomic Energy Regulatory Board (AERB), the national regulatory body, oversees the safety and has been mandated to frame safety policies, lay down safety standards and requirements. AERB has powers to monitor & enforce safety and regulatory provisions of the Act and the rules thereunder, in nuclear and radiation installations and practices.

1.1 NATIONAL NUCLEAR POWER PROGRAMME

Atomic Energy Programme in India is governed by Atomic Energy Act of 1962 and the rules framed thereunder. Atomic Energy Commission (AEC) is the apex body which lays down the policies for the national nuclear programme. The Department of Atomic Energy (DAE) is responsible for execution of policies laid down by the AEC. DAE is engaged in research, technology development and commercial operations in the areas of nuclear energy, related high-end technologies and also supports basic research in nuclear science and technology. The Nuclear Power Corporation of India Limited (NPCIL) is a Government owned company for design, construction and operation of the nuclear power plants in the country and is currently operating all NPPs. The Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI) is another Government company established for construction, commissioning and operation of the first 500 MWe Prototype Fast Breeder Reactor (PFBR) and future Fast Breeder Reactors. The Bhabha Atomic Research Centre (BARC) is the premier multi-disciplinary nuclear research centre of India having infrastructure for advanced research and development, with expertise covering the entire spectrum of nuclear science and engineering and related areas. The Indira Gandhi Centre for Atomic Research (IGCAR) is another national institution engaged in broad-based multi-disciplinary programme of scientific research and advanced engineering directed towards the Fast Breeder Reactor technology.

The organizational structure for Atomic Energy in India is shown in Annex 1-1.

Presently, there are 21 NPP units in operation in India, with an installed capacity of 5780 MWe as indicated in Table 1. Eight more units with a capacity of 6300 MWe are under construction / commissioning as indicated in Table 2. In addition, a number of new NPPs are planned to significantly increase the nuclear power base.

The first NPP in the country, TAPS -1&2, based on BWR, supplied by General Electric, USA, became operational in the year 1969. After completion of 30 years of operation, during the years 2000 to 2006, these plants underwent safety assessments for continued long term operation. Based on that review, a number of safety upgrades were implemented during the refueling outages of individual units and in a simultaneous long shutdown of both the units during November 2005 to January 2006. These safety upgrades were described in the Indian National Reports submitted to the 4th and 5th Review Meetings of the CNS.

The mainstay of India's nuclear power programme has been the PHWR. Two units of 200 MWe each (RAPS 1&2) were established in the 1970s, at Rawatbhata in Rajasthan, with the technical cooperation of AECL (Canada). Subsequently, in 1980s, two units of 220 MWe PHWRs

(MAPS-1&2) were constructed at Kalpakkam in Tamil Nadu, with indigenous efforts. Among these, presently RAPS -2 and MAPS -1&2 have undergone extensive safety upgrades.

Subsequently, India developed a standardised design of 220 MWe PHWRs. This design incorporated state of the art features viz. integral Calandria & end shields, two independent fast acting shut down systems, high pressure Emergency Core Cooling System (ECCS), water filled calandria vault and provision of double containment with passive vapour suppression pool. Four units of this standardised design were built, two each at Narora in Uttar Pradesh (NAPS-1&2) and Kakrapar in Gujarat (KAPS-1&2). These plants became operational in the 1990s. In later years eight more units of standardised 220 MWe PHWRs were built, four each at Kaiga in Karnataka (KGS-1 to 4) and Rawatbhata in Rajasthan (RAPS-3 to 6). Over and above the basic standardised 220 MWe PHWR, these plant designs have a more compact site layout and incorporated further improvements in safety features and containment.

In the 1990s, India undertook the design and development of 540 MWe PHWR. Two units based on this design became operational in 2005-2006 at Tarapur (TAPS- 3&4).Evolving on the 540 MWe PHWR design, India has developed a 700 MWe PHWR design, with limited boiling in the coolant channels. The construction of four such units is in progress, two each at the Kakrapar and Rawatbhata sites. In July 2015, Siting clearance was issued for establishing four more PHWR units of 700 MWe each at Gorakhpur in the state of Haryana.

In addition, India has setup two units of 1000 MWe LWRs (VVER based design), at Kudankulam (KKNPP-1&2) in Tamil Nadu, with the co-operation of Russian Federation. KKNPP-1 achieved first criticality on July 13, 2013 and subsequently after satisfactory completion of the commissioning activities the plant is operational at the rated capacity since end of December 2014. The KKNPP-2 achieved criticality on 10thJuly, 2016 and unit is in advanced stage of commissioning for power operation. Further, construction of two more units of similar design at Kudankulam (KKNPP-3&4) is in progress.

These reactors incorporate many advanced passive and active safety features. Post-Fukushima, extensive safety review of all Indian NPPs, especially with respect to external events was undertaken and the findings were presented in the National Report for the Second Extraordinary Review Meeting of CNS.

The construction of 500 MWe PFBR has been completed and preparatory activities for commissioning are in progress.

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

India has taken a number of steps towards development of necessary technology for utilization of thorium in the nuclear power programme. Use of U-233 as nuclear fuel derived from irradiated thorium has been demonstrated successfully in a neutron source research reactor KAMINI. India has developed AHWR of 300 MWe capacity for direct utilization of thorium. The design of AHWR incorporates state of the art advanced passive safety features. Pre-consenting safety review of the design of AHWR has been completed by AERB. A number of R&D activities have been taken up in BARC in connection with the development and detailing of AHWR systems and equipment. BARC has also set up a critical facility to validate the physics design of the AHWR.

1.2 EMERGING SCENARIO

The installed electricity generating capacity in India as of March 2016 is 298 GW. With this capacity, India is among the top five producers of electricity globally. The annual per capita electricity consumption for 2015-16 was 1075 kWh (Source: CEA, India). The contribution from nuclear energy to the overall installed capacity is currently about 2%. To enhance the power generation capacity, India is in the process of setting up Light Water Reactors with foreign collaboration while continuing its own programme of PHWR based NPPs and indigenously designed light water reactor based NPPs.

Four units of 700 MWe PHWRs are already under construction at KAPS-3&4 and RAPS-7&8. Recognizing the need for developing indigenous capability to support this growth, setting up / augmentation of facilities to manufacture major components by the leading industry partners has also been taken up.

1.3 NUCLEAR FUEL CYCLE

India's nuclear power programme is based on a closed fuel cycle. India has adopted this approach considering the objectives of maximum utilisation of the energy potential of available resources and minimisation of high level wastes.

Comprehensive fuel cycle technologies and facilities addressing the needs of both front end and back end have been developed and are in operation. Front end facilities including mining, milling and processing of ore and for fuel fabrication are operated by DAE units, the Uranium Corporation of India Limited (UCIL) and the Nuclear Fuel Complex (NFC) respectively. The back end technologies & facilities for reprocessing of spent fuel and the associated fuel fabrication facilities have been developed by DAE. For deployment and operation of back-end fuel cycle facilities, Nuclear Recycle Board has been established under DAE.

India has developed necessary technologies for safe management of the radioactive wastes arising out of the nuclear fuel cycle. This includes the vitrification technology for conditioning and fixation of the high level waste produced during spent fuel reprocessing in a glass matrix. The vitrified high level nuclear waste is stored in exclusive interim storage and surveillance facilities, prior to its final disposal in a Geological Disposal Facility (GDF) later. The vitrification plants and storage & surveillance facilities for the vitrified waste packages are in operation. The volumes of vitrified high level waste currently stored in Vitrified Waste Storage Facility are too small to call for setting up of a GDF. R&D work is in progress in the field of natural barrier characterization, numerical modelling and conceptual design pertaining to GDF. The timing of setting up of GDF in India is also linked to achieving the projected growth in the nuclear power programme. India has developed the necessary processes and technologies for partitioning of the actinides from High Level Liquid Waste (HLLW) resulting in further reduction of vitrified high level waste volume. A pilot plant employing this process is currently in operation. With the planned power profile, and deploying the technology of vitrification without resorting to partitioning of HLLW, the need for GDF is seen to be much later in time frame. Based on our future policy of deploying "Actinide Partitioning" for the HLLW, the setting up of a GDF will also get modified accordingly.

India plans to use the Cesium-137 separated from the HLLW using in-house developed novel extractants, for medical applications. The recovered Cesium-137 from High level radioactive waste is converted into non-dispersive vitrified glass form which is further encapsulated in stainless steel pencils to be used as sources for medical applications such as blood irradiators. This technology is currently being deployed in the commercial domain. Use of these technologies will simultaneously help in effectively addressing the objectives of minimisation of the radioactive waste generation as well as the radiotoxicity of the high level wastes in the nuclear power programme.

1.4 REGULATION OF NUCLEAR FACILITIES

Atomic Energy Regulatory Board (AERB) was established in 1983 under the provisions of the Atomic Energy Act 1962, and was provided with the necessary powers and mandate to frame safety policies, lay down safety standards and requirements for monitoring and enforcing the provisions under the Act and rules thereof. AERB follows multi-tier systems for its review and assessment, safety monitoring, surveillance and enforcement

AERB issues regulatory consents in stages viz. Siting, Construction, Commissioning and Operation during the life cycle of NPPs. It issues consent for a specified stage after conducting safety review and assessment. Compliance to the regulatory requirements is ensured through regulatory inspection, reporting obligations of utility and enforcement actions. Periodic Safety Review (PSR) of NPP is carried out once in ten years, as part of the process for renewal of license for operation.

AERB gets its technical support mainly from BARC. AERB has access to the outcome of the safety research performed by these organisations. Further as and when required, AERB commissions their services to perform research, analysis and studies in specialized areas of its interest. AERB also utilises their expertise to conduct its safety review and assessment function. Safety Research Institute (SRI) of AERB conducts independent safety studies in certain specific areas to supplement the regulatory review and assessment activities. AERB has also developed the capabilities for conducting independent verification of selected aspects of the safety analyses submitted by the applicants which is one of its strengths in fulfilling its mandate.

During March 16 – 27, 2015, AERB hosted an Integrated Regulatory Review Service (IRRS) Mission of IAEA. The IRRS Mission report identified 5 good practices, 13 recommendations and 21 suggestions. The Government and the Atomic Energy Regulatory Board have initiated steps to address the recommendations and suggestions identified. An action plan towards implementation of the recommendations/suggestions has been finalised and its implementation is in progress. The Government of India has made the report of the IRRS Mission publicly available through the website of AERB.

1.5 INDUSTRIAL INFRASTRUCTURE FOR NUCLEAR POWER

Towards developing various technologies for the envisaged nuclear power programme in the country, a number of facilities were established by DAE in the early years of the nuclear power programme. These included uranium and thorium extraction plants, fuel fabrication plant, heavy water production facilities, research reactors, a fuel reprocessing plant, waste treatment facilities and a number of radiological laboratories for radioisotope production, radiochemistry research and radio-metallurgy studies. Significant up-gradation and developmental efforts were undertaken in initial days for manufacturing and precision machining jobs to meet the quality standards of nuclear industry. Today almost all ferrous and non-ferrous materials, components and equipment required for nuclear power plants are manufactured indigenously.

India has heavy engineering and manufacturing facilities in both public and private sectors. It is capable of manufacturing equipment / components like coolant tubes, calandria tubes, calandria and end shields for PHWRs, steam generators, turbines, electrical equipment, heat exchangers, pumps, pressure vessels, fuelling machines etc. The developments in manufacturing of electrical machines, electrical and electronic accessories and Control & Instrumentation items such as large size motors, high quality conductors, sophisticated control panels and computer based control systems progressed in line with requirements of nuclear power projects. In recent times, a joint venture of NPCIL and another public limited company was established to manufacture critical heavy forgings for major primary components of a NPP such as Steam Generators and Pressurizers. These forgings for 700MWe PHWR have been successfully developed and delivered. The development of forgings for Reactor Pressure Vessel (RPV) for IPWR has also been initiated. Concurrently with the manufacturing technologies, the non-destructive examination methods and related equipment such as optical and laser based instruments, etc. have been developed.

The maturity of the industry and its capability to take up mega package contracts has contributed significantly in the reduction of gestation time of nuclear power projects in India.

1.6 HUMAN RESOURCE DEVELOPMENT

In order to create a competent pool of well-trained scientists and engineers, a specialized training school at BARC was established in 1957 after recruiting graduates and post graduates. The Homi Bhabha National Institute (HBNI) established under DAE conducts post-graduation and doctoral programmes in areas of nuclear science and technology. With the growth of nuclear power, NPCIL set up its own Nuclear Training Centres (NTCs) to meet its demand. Training schools have also been set up at the Raja Ramanna Centre for Advanced Technology, Indore (2000), Nuclear Fuel Complex, Hyderabad (2001) and IGCAR, Kalpakkam (2006) to meet the expanding needs. The core of the human resource for the nuclear power programme comes through these training centres. In addition, experienced manpower from conventional power sector and industry is also inducted to meet the demand.

The Indian universities, science and engineering institutes, polytechnics, and industrial training institutes form the basic educational infrastructure from which engineers/scientists, technicians and skilled tradesmen are recruited and subsequently trained to suit the job needs.

Networking with the Indian Institutes of Technology (IITs) has been strengthened and post-graduate courses in nuclear engineering have been started at several institutes. Sponsored post-graduate program called ‘DAE Graduate Fellowship Scheme’ were started at all the IITs. Board of Research in Nuclear Sciences (BRNS) under DAE provides another avenue for networking by sponsoring research projects in the field of Nuclear Science and Engineering at various educational institutes.

NPCIL’s technical manpower includes freshly recruited engineers who go through one year of training in DAE/BARC Training School or in Nuclear Training Centres of NPCIL. It also hires experienced manpower from open market. NPCIL provides challenging work environment, attractive remunerations and promotional avenues to its employees for motivating them to continue their career with NPCIL. It also provides excellent quality of life at its residential colonies by adequately taking care of their health, education, transportation and recreational needs.

The initial manpower of BHAVINI for construction, commissioning and operation of the Prototype Fast Breeder Reactor has been inducted from NPCIL and IGCAR. BHAVINI has also undertaken recruitment of graduate engineers and personnel at various grades. IGCAR training centre caters to training needs for Fast Reactors. The operation staff is currently undergoing training at IGCAR and NPCIL plants and also engaged in the preparatory activities for commissioning of PFBR. The qualification and licensing of the staff will be in line with the norms established by AERB for operation of PHWR.

AERB is continuously augmenting its human resource to meet the demand arising from the expanding nuclear power programme and increasing number of radiation facilities in the country. AERB inducts fresh technical and scientific staff from DAE’s training schools and nuclear training centres. It also hires graduate engineers and sponsors them for Masters programmes in the Indian Institutes of Technology through the AERB Graduate Fellowship Scheme (AGFS) who later serve as AERB staff. Experienced professionals are also recruited from open advertisements. AERB imparts intensive in-house orientation training to the newly recruited staff. In addition, refresher courses are regularly conducted on various topics of regulatory and safety importance to enhance the competence of the staff. AERB colloquia are organised on topics of current interest and on new developments in various fields.

1.7 COMMITMENT TO THE CONVENTION ON NUCLEAR SAFETY

India is committed to implement the provisions of the Convention on Nuclear Safety. This National Report demonstrates how these provisions are implemented and the same is described under the respective articles.

After the ratification of the Convention in 2005, India submitted the National Reports as well as answers to the questions raised on the Reports in a comprehensive and timely manner in all the Review Meetings as well as the Extraordinary Meetings of the Convention. India has actively participated in the Review Process of the Convention and engaged a large number of experts to undertake the review of the National Reports of the Contracting Parties. India provided services of its experts as officers in all the Review Meetings of CNS after ratifying the Convention. India has been actively contributing in the review process that began post Fukushima nuclear accident in Japan, to enhance the effectiveness of the Convention.

During the Diplomatic Conference held on February 9, 2015, India actively supported the adoption of the Vienna Declaration on Nuclear Safety by consensus. Soon after the second Extraordinary meeting of the CNS in August 2012, India had taken steps to incorporate the lessons learned from the Fukushima accident into its regulatory requirements with respect to siting and design of NPPs. These requirements are in line with the latest IAEA standards. As mentioned earlier, India follows the Periodic Safety Review system as the part of the basis for renewal of operating licenses of NPPs, which enables evaluation of safety of operating NPPs vis-à-vis the latest requirements / practices as well as timely implementation of the identified safety enhancements. This approach demonstrates the India’s commitment to the CNS as well as the Vienna Declaration on Nuclear Safety.

1.8 NATIONAL REPORT TO THE 7th REVIEW MEETING OF CNS

The national report of India to the 7th review meeting of the Convention is prepared in line with the guidelines contained in information circular INFCIRC/572/Rev.5 on “Guidelines regarding National Reports under the Convention on Nuclear Safety”, the summary report of the 6th Review

Meeting, additional recommendations for the preparation of national reports for the 7^{th} Review Meeting dated October 8, 2015, and the letter written by President of 7^{th} Review Meeting of CNS to the Contracting Parties in February 2016.

In the 6^{th} Review Meeting of CNS, India had identified certain challenges and planned measures to further improve safety. These are detailed in the relevant articles of the report. The recommendations adopted at the Plenary Sessions of the 6^{th} Review Meeting have been addressed and future activities for further enhancement of safety are brought out. An account of the actions taken with respect to the issues highlighted during the 6^{th} Review Meeting of CNS has also been included under the relevant articles.

Further the report brings out the aspects related to the Vienna Declaration on Nuclear Safety in the Summary as well as under articles 6, 14, 17, 18 and 19.

Table - 1 : NPPs in Operation as of August 2016

Unit	Type	Gross Capacity (MWe)	Licensee / Owner	Reactor Supplier	Commencement of Operation
KGS-1	PHWR	220	NPCIL	NPCIL	Nov-2000
KGS-2	PHWR	220			Mar-2000
KGS-3	PHWR	220			May-2007
KGS-4	PHWR	220			Jan- 2011
KAPS-1	PHWR	220			May-1993
KAPS-2	PHWR	220			Sep-1995
MAPS-1	PHWR	220			Jan-1984
MAPS-2	PHWR	220			Mar-1986
NAPS-1	PHWR	220			Jan-1991
NAPS-2	PHWR	220			Jul-1992
RAPS-1#	PHWR	100	NPCIL / DAE	AECL, CANADA	Dec-1973
RAPS-2	PHWR	200	NPCIL	AECL/ DAE	Apr-1981
RAPS-3	PHWR	220		NPCIL	Jun-2000
RAPS-4	PHWR	220			Dec-2000
RAPS-5	PHWR	220			Feb-2010
RAPS-6	PHWR	220			Mar- 2010
TAPS-1	BWR	160		GE, USA	Oct-1969
TAPS-2	BWR	160			Oct-1969
TAPS-3	PHWR	540		NPCIL	Aug-2006
TAPS-4	PHWR	540			Sep-2005
KKNPP-1	PWR	1000		ASE, RUSSIA	Dec, 2014

 # Unit under shutdown since 2004.

Table - 2 : NPPs under Siting, Construction and Commissioning as of August 2016

Project	Type	Gross Capacity (MWe)	Licensee/ Owner	Reactor Supplier	Start of Construction
KKNPP-2	PWR	1000	NPCIL	ASE, RUSSIA	Mar-2002
PFBR	PFBR	500	BHAVINI	BHAVINI	Oct-2004
KAPP 3&4	PHWR	700 each	NPCIL	NPCIL	Nov-2010
RAPP 7&8	PHWR	700 each	NPCIL	NPCIL	Jul-2011
KKNPP 3&4	VVER	1000 each	NPCIL	ASE, RUSSIA	under launch
GHAVP 1 to 4	PHWR	700 each	NPCIL	NPCIL	Siting consent issued

Annex 1-1 Organisational Structure for Atomic Energy in India

Atomic Energy Commission

Atomic Energy Commission (AEC) is the apex body of the Central Government for atomic energy that provides direction on policies related to atomic energy. The members of AEC include, among others, eminent scientists & technocrats, secretaries of ministries and senior most officials from the office of the Prime Minister. The AEC reports to the Prime Minister.

Atomic Energy Regulatory Board

Atomic Energy Regulatory Board (AERB) is the national regulatory body having powers to frame safety policies, lay down safety standards & requirements and powers to monitor & enforce provisions under the Act and rules thereof, in nuclear and radiation installations and practices. AERB reports to AEC.

Department of Atomic Energy

Development and implementation of nuclear power and related nuclear fuel cycle activities and research & development activities are carried out in various units under the DAE. The DAE organisation is divided into four major sectors, viz. Research & Development sector, Industrial sector, Public Sector Undertakings and Services & Support sector. The DAE also provides for the interaction needed between the production and R&D units. The organisations engaged in the area of Atomic Energy in different sectors are as given below and the organisation structure is shown in Figure 1.

i. Research and Development sector includes Bhabha Atomic Research Centre (BARC), Indira Gandhi Centre for Atomic Research (IGCAR), Atomic Minerals Directorate for Exploration and Research (AMD), Raja Ramanna Centre for Advanced Technology (RRCAT) and Variable Energy Cyclotron Centre (VECC). Board of Research in Nuclear Sciences (BRNS) and National Board for Higher Mathematics (NBHM) provide funding to universities and other national laboratories. Homi Bhabha National Institute (HBNI) is an institute having academic programmes which are run by the R&D centres and grant-in-aid institutions.

ii. There are several grant-in-aid institutes like Tata Institute of Fundamental Research (TIFR), Institute for Plasma Research (IPR) and Saha Institute of Nuclear Physics (SINP) under DAE.

iii. Industrial sector includes Government owned units of Heavy Water Board (HWB) for the production of heavy water, Nuclear Fuel Complex (NFC) for the fabrication of nuclear fuel, zircaloy components and stainless steel tubes, Nuclear Recycle Board for deployment & operation of back-end nuclear fuel cycle facilities, and Board of Radiation & Isotope Technology (BRIT) for processing and supply of radioisotopes and developing technologies for radiation and isotope applications.

iv. Public Sector Enterprises along with their activities under the control of DAE are as follows:

- Nuclear Power Corporation of India Limited (NPCIL) engaged in the design, construction, commissioning and operation of the nuclear power plants;
- Uranium Corporation of India Limited (UCIL) engaged in mining, milling and processing of uranium ore;
- Indian Rare Earths Limited (IREL) engaged in mining and separation of beach sand minerals to produce ilmenite, rutile, monazite, leucoxene, zircon, silimanite and garnet and chemical processing of monazite to obtain thorium and rare earths;
- Electronics Corporation of India Limited (ECIL) engaged in design and manufacture of control and instrumentation equipment related to atomic energy and also to other sectors;
- Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI) for setting up fast reactor based nuclear power plants.

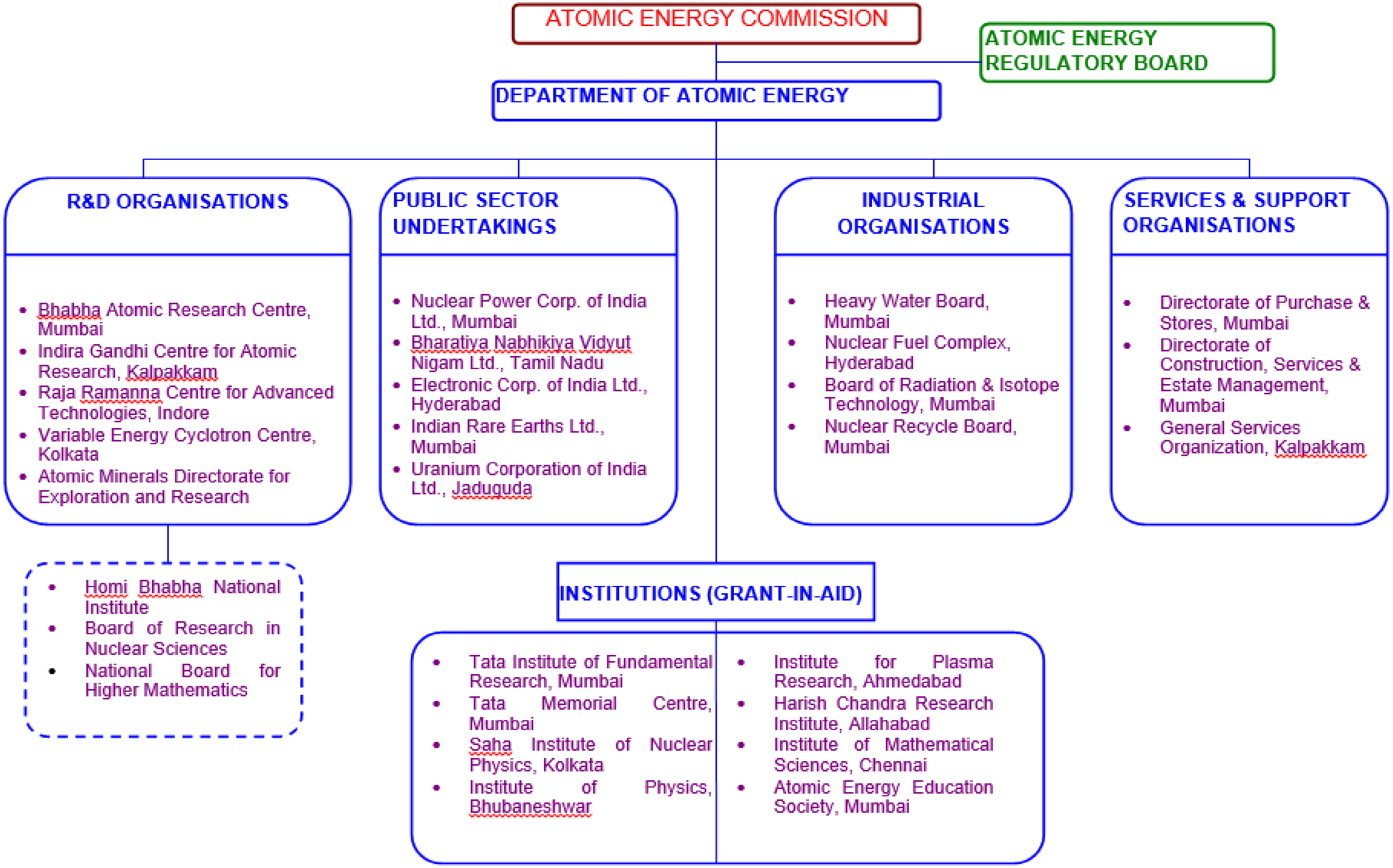


Figure - 1 : Organisational Structure for Atomic Energy in India

SUMMARY

Nuclear energy is an important element in India's energy mix for sustaining rapid economic growth. India remains firmly committed to its indigenous nuclear power programme and is planning a major expansion of nuclear installed capacity. To facilitate speedy enhancement of the nuclear power generation capacity, India is in the process of setting up Light Water Reactor based NPPs with foreign collaboration in addition to capacity addition with the setting up of new NPPs of indigenous designs. This is being pursued with full regard to safety and environment.

SAFETY ENHANCEMENTS SUBSEQUENT TO THE FUKUSHIMA DAIICHI NUCLEAR ACCIDENT

The nuclear accident at Fukushima Daiichi nuclear power plants in Japan in March 2011 had brought the safety of NPPs under scanner. Immediately after the accident at Fukushima, Hon'ble Prime Minister of India re-emphasized that safety of nuclear power plants is a matter of highest priority for the Government and called for safety audits of Indian Nuclear Power Plants (NPPs). Nuclear Power Corporation of India Ltd. (NPCIL), the utility, undertook a review to identify and implement the immediate measures for ensuring safety of the NPPs against extreme natural external events. This review considered the measures required for surviving situations involving complete loss of electrical power and water supplies to the NPP. The actions taken for implementation of the enhancement measures based on this review were completed in a very short timeframe. Independent of this, Atomic Energy Regulatory Board (AERB) commissioned a high level committee of experts, to review the capability of Indian NPPs to withstand extreme external events like earthquakes, tsunami, cyclone, flood, volcanic activity etc. and adequacy of design provisions to ensure safety in case of such events both within and beyond the design bases of the NPP. In parallel, AERB undertook site specific special regulatory inspections focusing on the changes, if any, in the likely impact of external events on the existing plant systems.

The findings of both AERB and NPCIL reviews have reconfirmed the inherent strengths in design, practices and safety regulation followed in India. The NPPs in India can withstand currently defined design basis external events (with sufficient margins available), and their consequential events such as sustained loss of electrical supplies (prolonged Station Blackout) and loss of normal heat sink. However, based on the assessment, certain safety enhancements were identified for strengthening the defences against the rare external events exceeding the design bases and enhancing severe accident mitigation capabilities. The outcome of the above reviews and the special regulatory inspection results were extensively deliberated for identifying the safety enhancement actions and the timeframe for their implementation. These actions were classified as short term, medium term and long term measures. India's National Reports addressing these aspects were presented during the Second Extraordinary Meeting and the 6th Review Meeting of the Convention on Nuclear Safety.

India has been participating in several of the International initiatives to learn lessons from the accident. Apart from the peer review process of the CNS, Indian experts have been sharing the findings of these safety reviews with the experts from the other countries through a number of fora, which had shown that the safety enhancement measures being implemented in the Indian NPPs are in line with the best practices elsewhere in the world.

As of now, implementation of the short term and medium term actions has been completed to the satisfaction of AERB in all the NPPs, operating and under construction. The work for implementation of the long term measures is in progress, including enhancement of severe accident management, hydrogen management and establishment of on-site emergency support facilities, which can remain functional even under extreme situations.

DEVELOPMENT AND REVISION OF SAFETY DOCUMENTS

AERB has so far issued more than 150 regulatory documents in various areas of safety regulation. These documents are reviewed and updated periodically based on experience and scientific developments and to take account of the guidance given in IAEA documents. Soon after the 2nd Extraordinary Meeting of CNS in 2012, AERB started the work of reviewing the regulatory requirements for the nuclear power plants, in the light of the lessons from the Fukushima accident. Based on this review, AERB identified the need for developing new regulatory documents as well as revisions in the existing documents to address the lessons learned from the Fukushima accident. In this regard AERB has already issued two regulatory documents namely the Safety Code on Site Evaluation of Nuclear Facilities - AERB/NF/SC/S (Rev.1) issued in 2014 and Safety Code on Design of Light Water Reactor Based Nuclear Power Plants - AERB/NPP-LWR/SC/D issued in 2015. These Safety Codes contain the relevant safety and regulatory requirements consistent with the Vienna Declaration of Nuclear Safety.

STRENGTHENING OF EMERGENCY PREPAREDNESS

Indian regulations require that the emergency preparedness and response programme is established and the essential infrastructure and resources are created prior to issuance of operating license. Specific requirements with respect to emergency preparedness in NPPs are prescribed in AERB safety codes and guides. In 2005, the central government enacted a separate legislation (the Disaster Management Act), to institute the National Disaster Management Authority (NDMA) that also has the responsibility to strengthen the existing nuclear/radiological emergency management framework at district, state and national level. A National Disaster Response Force (NDRF) has been developed under NDMA with clear command and control to respond to emergencies including nuclear and radiological emergencies. NDRF personnel are also trained for handling nuclear and radiological emergencies.

Review of emergency preparedness and response plans got specific attention subsequent to Fukushima accident. AERB reviewed all the requirements which included onsite management capability during accidents at multi-unit site along with consideration of serious damage to the infrastructure and surroundings. Simultaneously, NDMA had taken up special exercises at each NPP site, ensuring participation of all the stakeholders and government agencies including training of personnel involved at various levels. These exercises were in addition to the ones conducted at plant, site and off-site domain in every three months, one year and two years, respectively.

AERB has also completed review of the regulatory documents relating to emergency preparedness and response. Based on the review, while AERB has revised the regulatory document on ‘Criteria for Planning, Preparedness and Response for Nuclear or Radiological Emergency’, the work on revision of the regulatory document on ‘Preparation of Off-Site Emergency Preparedness and Response Plans for Nuclear Emergency’, is in progress. These revisions intend to suitably incorporate the provisions of IAEA safety requirements.

COMMITMENT TO THE IAEA ACTION PLAN

India is committed to implement the IAEA Action Plan on Nuclear Safety. India’s own initiatives have been generally in line with the Action Plan. India has strong international linkages in the area of nuclear safety. Indian experts are participating in IAEA’s International Experts Meetings, workshops, expert groups and international peer review missions, including WANO missions.

NPCIL is engaged in the activities undertaken on other fora for operators like WANO and the COG. Apart from regular peer reviews of the NPPs by the WANO, NPCIL had hosted the WANO Corporate Peer Review in 2015.Earlier, India had invited the IAEA OSART mission for the peer review of Rajasthan Atomic Power Station 3&4 in November, 2012 with the Follow up Mission in February 2014. The mission was performed using the revised scope and modules updated form the lessons learnt from the Fukushima accident. The mission found presence of strong safety culture at the nuclear power plant and has recorded many good practices. NPCIL has taken steps to implement the recommendations and suggestions made by the OSART Mission to further improve operation of the NPP. India has declassified the OSART mission report for making it available in IAEA - OSMIR (OSART Mission Results) database.

NPCIL participated in COG - CANDU Industry Integration Team (CIIT) to discuss safety enhancements post Fukushima accident in countries operating CANDU/PHWRs and it was noted that safety enhancements made in Indian NPPs are in line with other countries.

AERB hosted the IRRS Mission for peer review of the regulatory framework for safety of NPPs during March 16 – 27, 2015. The final report of the Mission was submitted to the Government on August 31, 2015. The report of this IRRS Mission has been made public on the website of AERB. The Peer Review Mission has identified certain suggestions, recommendations and good practices. India is committed to address the recommendations and suggestions made by the IRRS Mission to further enhance the regulatory framework and processes. Actions are in progress for addressing these recommendations and suggestions.

UPDATES ON TOPICS FROM PREVIOUS REVIEW MEETINGS

Strengthening Legislative framework

Atomic Energy Act, 1962 and rules framed thereunder provide the main legislative and regulatory framework pertaining to atomic energy in the country. The Central Government has been in the process of creating a separate primary legislation for regulating nuclear and radiological safety in the country. Nuclear Safety Regulatory Authority (NSRA) Bill, 2011 was introduced in the Parliament to fulfill this objective. However, the term of the Lok Sabha (Lower House of the Parliament) expired before the bill could be taken up. A similar bill is being processed with a view for introduction in the current term of the Parliament.

Periodic Safety Review (PSR)

As required by the Indian regulation for renewal of license for operation, safety assessment of TAPS-1&2, KAPS-1&2 and MAPS-1&2 were conducted by NPCIL as a part of PSR. Based on the satisfactory review of the report of these assessments, AERB renewed the licenses for operation of these NPPs.

Probabilistic Safety Assessment (PSA)

In continuation of Level-1 and Level-2 PSA studies, reported in previous national reports, NPCIL has expanded Level-1 PSA for a typical 220 MWe PHWR unit. This includes internal events PSA for low power operation, shutdown state, internal flood and internal fire; and seismic PSA for external events. The submitted reports are being concurrently reviewed by AERB.

Severe Accident Management (SAM)

A systematic programme for accident management had been initiated for the operating NPPs. NPCIL has developed generic accident management guidelines and identified additional measures required for strengthening defence against severe accidents. These efforts address the lessons learned from Fukushima. AERB completed its review of the generic accident management guidelines. The plant specific measures for enhancing cooling capability, provision for diverse backup power sources etc. that were specific to prevent the escalation of accident to core melt scenario have been implemented. Plant specific accident management guidelines on these measures have been issued and operators have been trained on these aspects. Significant progress has been made towards severe accident mitigation efforts that include provision of Passive Catalytic Recombiner Devices (PCRD) to strengthen the hydrogen management, containment filtered venting to maintain containment integrity and On-site Emergency Support Centre for effective handling of accident situation.

Reviews of projects under construction

First of the two units of 1000 MWe VVER of Russian design at Kudankulam was issued the license for operation in the year 2015 by AERB, after satisfactory review of results of the commissioning tests and performance during initial operation. The second unit has achieved criticality on July 10, 2016 and is in advanced stage of commissioning for power operation. The construction of 500 MWe pool type, sodium cooled, mixed oxide (MOX) fuelled, Prototype Fast Breeder Reactor (PFBR) has been completed. Preparatory activities for commissioning of the

PFBR are in progress. AERB is currently reviewing the application for construction consent for two additional units of 1000 MWe VVERs (units 3&4 of KK NPP) at the Kudankulam site (identical to the 2x1000 MWe VVER units already built at the site). AERB has issued permission for excavation (first sub-stage of construction consent).

Construction of the four units of indigenously designed 700 MWe PHWRs, coming up at the Rawatbhata site in Rajasthan (RAPS-7&8) and Kakrapar site in Gujarat (KAPS-3&4) is presently in advanced stage. AERB had issued the regulatory clearance for major equipment erection for these units during 2014 & 2015.

In July 2015, AERB has issued the siting consent for establishing four more units of 700 MWe PHWR units at Gorakhpur in the northern state of Haryana. Review of the application for construction consent for the first two units is in progress.

Design support to Operating NPPs

The Central Government had created Nuclear Power Corporation of India Limited (NPCIL) with the responsibility for design, construction, commissioning and operation of nuclear power plants. The benefit of this "one house approach" is that the operators continue to get design support during the life cycle of nuclear power plants. NPCIL also creates specific design support groups for continued support to the operators of new and imported reactor designs. NPCIL has its own research and development facilities, where experiments/tests related to safety, design and ageing are performed. The facilities are also engaged in development & testing of innovative features being incorporated in 700 MWe PHWRs and systems for enhancing containment performance during severe accidents.

Human and organizational factors

Human and organizational factors are considered in all the activities of NPCIL and AERB. They continue to remain the key focus area. Feedback of experience from operation, construction, design and safety reviews remains the main input for continual improvement on these fronts. Safety culture assessment of NPPs is part of the integrated management system of NPCIL. It has instituted a system of periodic audit by a corporate mechanism for safety culture assessment. AERB has established a comprehensive system towards competence enhancement of its personnel and conscious efforts have been made to strengthen the safety culture at regulatory body.

Use & control of contractors

In Indian NPPs, contractors are not employed for routine operation in critical areas of the main plant. The contractors are restricted to carry out operational activities in the auxiliary facilities like switch yard, DM water plant, chiller plant, etc. During the biennial maintenance shutdowns, contractor's manpower is used to supplement the plant personnel. In this period, the contractor's personnel work alongside the regular plant personnel and no independent responsibilities are assigned to them. Such personnel are provided specified training, including radiation protection.

ADDRESSING THE VIENNA DECLARATION ON NUCLEAR SAFETY

The practices in India with respect to design, operation and regulation of NPPs integrate the benefits from the principles of learning from experience, research and development, periodic safety assessments, safety enhancements and international engagement. The safety regulations in India are kept updated with the IAEA safety documents and other international benchmarks in the relevant area, thus ensuring that the new constructions follow the latest requirement. The programme for periodic renewal of operating licenses for the Indian NPPs facilitate regular safety evaluations against the current requirements and timely implementation of practicable safety enhancements. These aspects in relation to the Vienna Declaration on Nuclear Safety are described in detail under articles 6, 14, 17, 18 and 19. These have been consolidated and summarized below.

India has been following an active nuclear power programme, with units being added more or less at a regular pace. With India pursuing an indigenous nuclear power programme, the NPP designs have been seeing enhancements over time, particularly in respect of safety, in tune with the prevailing international benchmarks and best practices. This has facilitated the design approach for the Indian NPPs to stay up to date with the state of art.

From the early phase of the nuclear power programme, India has been following a proactive approach towards safety enhancements in the NPPs. The regulatory processes, which evolved over a period of time have adopted many of the best practices with respect to safety and regulation. Indian regulatory system always placed strong emphasis on learning from experience and using it to enhance safety. This character has helped the nuclear industry, the regulator and the R&D community to evolve with the times to achieve and maintain high level of safety in accordance with the societal expectations. In line with this, the regulatory system incorporates a system of ‘special safety reviews’, undertaken following major events, wherein the implications of such experience and lessons are reviewed for identifying and implementing safety enhancements. Indian NPPs have undergone many such reviews, examples of which include the Three Mile Island accident of 1979, the Chernobyl accident of 1986, the fire incident at Narora Atomic Power Station (NAPS) in 1993, the flood incident at the Kakrapar Atomic Power Station (KAPS) in 1994, the tsunami at the Madras Atomic Power Station (MAPS) in 2004, the Fukushima accident in 2011, and pressure tube leaks at KAPS in 2015-16. All these reviews have resulted in enhancements in the safety features and regulatory requirements.

The regulatory system in India has adopted the Periodic Safety Review (PSR), which incorporates addressing the cumulative effects of ageing and comparison with the current safety requirements / practices, to identify the need for safety enhancements in the existing NPPs. In the regulatory system in India, license for operation of NPP has a maximum validity period of five years. Renewal of the licenses is based on a comprehensive safety review once in 5 years and conduct of PSR, once in 10 years. Linking of the PSRs and renewal of operating licenses helps in ensuring that the identified safety enhancements are implemented timely.

The National Report brings out a detailed account of the safety enhancements carried out in the NPPs in the section under Article 6. The PSR along with operational experience feedback programme and the special safety reviews of Indian NPPs conducted in the past have led to substantial safety upgrades in older NPPs and the design of NPPs built later. The safety reviews carried out following the Fukushima accident have shown the inherent strengths in the design, operational and regulatory practices and requirements associated with the Indian NPPs. The strengthening measures identified and being implemented for the Indian NPPs are associated mainly with enhancing the resilience of the plants to cope with extreme external events exceeding the design bases and to strengthen the provisions for mitigation of severe accidents.

The Atomic Energy Regulatory Board is mandated to formulate the necessary regulations and requirements with respect to safety of nuclear and radiation facilities. AERB has well-established systems and process for development of regulatory documents which consider in detail the requirements of relevant IAEA documents, feedback from operating experience as well as the current best practices. These regulatory requirements are reviewed periodically and updated taking account of the latest IAEA requirements in the relevant area. As mentioned earlier, AERB has recently issued the regulatory documents related to site evaluation of nuclear facilities and design of light water reactor based NPPs, which incorporate the lessons learned from the Fukushima Daiichi nuclear accident. The requirements in these regulatory documents are in line with the latest requirements specified in the IAEA documents.

As brought out in the National Reports to the 2nd Extraordinary Meeting and 6th Review Meeting of the CNS, certain safety enhancements were identified for Indian NPPs based on the review conducted post Fukushima. All the NPPs that were in operation and under construction were directed to implement the identified safety enhancements in a timely manner. In parallel, AERB carried out review of its existing regulatory documents with regard to the lessons from the Fukushima accident. These aspects were also brought out in the national report of India for the

6th Review Meeting of CNS. Based on this review, AERB is progressively revising the identified documents, as per its established process, for incorporating the lessons from Fukushima, as well as to take account of the aspects in the latest IAEA documents.

The safety enhancements being implemented and the systems established for conducting systematic and regular reviews would help in addressing the Vienna Declaration on Nuclear Safety. Further as brought out above, the actions by AERB for incorporating the lessons from Fukushima accident in the regulatory documents ensure that the national regulations incorporate the requirements consistent with the Vienna Declaration on Nuclear safety.

CHALLENGES AND PLANNED MEASURES

India as a country with serious interest in nuclear power to meet its developmental aspirations, remains committed to achieving and maintaining the highest level of safety at its nuclear facilities. India is fully committed to learning the lessons from the Fukushima accident and to take timely steps to enhance safety of operating NPPs as well as incorporate these lessons in siting, design and construction of new NPPs. The planned measures are directed to meet these objectives. These include implementation of planned safety measures identified during post Fukushima reviews, revision of safety documents, enhancement of offsite emergency preparedness and severe accident management measures including firming up of criteria for additional safety features and complimentary provisions to limit the consequences of severe accidents. India has a challenge to prepare itself for the planned rapid expansion of nuclear power in the coming years.

In particular, the planned measures identified for the coming three years include completion of the ongoing implementation of long term measures emanating from the lessons learned from Fukushima accidents viz. provision for filtered venting of containment, hydrogen management measures, including homogenisation of containment atmosphere, installation of passive catalytic recombiner devices, on-site emergency support center capable of withstanding extreme external events and completion of ongoing revision of regulatory documents.

The PHWR unit KAPS-2 had an incident of incipient leakage of coolant from a coolant channel on July 1, 2015. The unit was brought to safe shutdown by operator. The other unit at same station (KAPS-1) also encountered an incident of leakage from a coolant channel on March 11, 2016. The leakage in this case was of higher magnitude, resulting in auto actions of safety systems to maintain core cooling. Based on the investigation findings so far immediate corrective measures have been taken to confirm safety of coolant channels in other operating reactors through conduct of additional inspections. The investigations done at KAPS units have indicated presence of localized corrosion spots which is unusual and has not been seen in other reactors. Establishing the causes of this corrosion seen in KAPS units and whether this has contributed to the leakage incidents is an immediate challenge.

ARTICLE 6: EXISTING NUCLEAR INSTALLATIONS

Each Contracting Party shall take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible. When necessary in the context of this Convention, the Contracting Party shall ensure that all reasonably practicable improvements are made as a matter of urgency to upgrade the safety of the nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shutdown may take into account the whole energy context and possible alternatives as well as the social, environmental and economic impact.

6.0 GENERAL

At present twenty one nuclear power reactors in India are being operated by NPCIL. The first NPP in the country, TAPS-1&2, boiling water reactors (BWR), supplied by General Electric, USA, became operational in the year 1969. Thereafter, the mainstay of India's nuclear power programme has been the Pressurised Heavy Water Reactor (PHWR) technology. The first two 200 MWe units (RAPS-1&2) were established in the 1970s, at Rawatbhata in Rajasthan, with the technical cooperation of AECL (Canada). In 1980s, two 220 MWe PHWRs (MAPS-1&2) were constructed at Kalpakkam in Tamil Nadu, with indigenous efforts. Subsequently, indigenous design for standardised 220 MWe PHWRs was developed and two units at Narora were commissioned in early 1990s. The design incorporated the state of art features viz. integral calandria & end shields, two independent fast acting shut down systems, high pressure ECCS, water filled calandria vault and provision of double containment with passive vapour suppression. Additional ten units of 220 MWe PHWRs based on this standard design with compact layout and further improved safety features and containment were constructed in the next two decades and are in operation.

In 1990, India undertook the design and development of 540 MWe PHWR. Two units based on this design became operational in 2005-2006 at Tarapur (TAPS-3&4). This design is now further modified to incorporate limited boiling of the coolant in the channels at the outlet and the capacity has been increased to 700 MWe.

India has set up two units of 1000 MWe light water reactors, at Kudankulam (KKNPP-1&2) in Tamil Nadu, with co-operation of Russian Federation. KKNPP-1 is in commercial operation since December 31, 2014. The KKNPP-2 achieved criticality on July 10, 2016 and unit is in advanced stage of commissioning for power operation.

Currently, four pressurized heavy water reactors (700 MWe) are under different stages of construction. Further, construction activities have started for two light water reactors (1000 MWe). Preparatory activities for commissioning of one unit of PFBR (500 MWe) are in progress.

6.1 PERFORMANCE AND SAFETY STATUS OF OPERATING NPPs

6.1.1 Collective dose to occupational workers

There exists a practice for preparation of annual budget for collective exposure of occupational workers for each station based on previous year's exposures and also taking account of the jobs to be taken up during the year. This budget is reviewed and approved by AERB at the beginning of each calendar year. Finally at the end of the calendar year, the actual collective dose consumed is also reviewed to get the feedback on the operating practices.

In the last three years collective dose consumed was around 1.2 person Sievert/unit/year for old NPPs, 0.6 person Sievert /unit/year in the new generation NPPs (i.e. KAPS-1&2 onwards). The collective dose is around 0.1 person Sievert/unit /year for KKNPP-1.

6.1.2 Radiological impact due to operation of NPPs

The radiological impact due to operation of NPPs on the environment for each site is monitored by the Environmental Survey Laboratory (ESL) , which is established by BARC (a TSO of AERB) well before the commencement of operation of NPP. The ESL, which is independent of the utility, carries out periodic surveillance of the areas around NPPs, based on which the radiological impact of NPP operation on the environment and public around the NPP is assessed annually.

The aspects related to the impact of plant operation on the environment and public are also re-assessed during PSR of the NPPs. The area up to a distance of up to 30 km is covered under the environmental survey programme.

The estimated dose at the plant boundary due to operation of NPPs during last three years is negligible as compared to limits prescribed by AERB. The details are given in Article – 15.

6.1.3 Operational performance of NPPs

Operating nuclear installations in India are subjected to continuous appraisal of safety by NPCIL and AERB as per the established requirements. The operational performance and significant events are reviewed and the required modifications are implemented.

The operational performance of all the NPPs operated by NPCIL has remained satisfactory over the years. Unit 5 of the Rajasthan Atomic Power Station became the second longest running reactor in the world by being in operation for 765 days continuously. KAPS-1 has experienced an incident of failure of pressure tube on March 11, 2016, which led to declaration of a plant emergency. Currently, the unit is under shutdown for investigations. KAPS-2 is also under shutdown since July 1, 2015, after the annulus gas monitoring system of the unit indicated a leak from one of the pressure tubes. The additional information about these incidents is given in Section 6.2.

6.1.4 In-Service Inspections (ISI)

All the nuclear power plants have established the ISI programme approved by AERB. The programme covers all the important equipment and piping of primary and secondary systems. In addition, the programme covers areas vulnerable to flow assisted corrosion. ISI results are analyzed to assess the health of Structures, Systems and Components (SSCs) and to take necessary steps to ensure health of the systems and components.

In-Service Inspection of coolant channels for PHWRs is being carried out using a specially developed tool called BARCIS. The critical parameters such as ID, wall thickness, spacer location, as well as presence of flaws, creep / growth, hydrogen content etc. are monitored at specified intervals as part of the programme.

Inspections were done on the reactor pressure vessels of TAPS-1&2 as part of its health assessment for continued operation.

In-service inspection programme of nuclear power plants is periodically updated based on operating experience. The program for inspection of coolant channels and PHT system feeders has been augmented based on incidents of pressure tube leak in KAPS-1&2 and leak in PHT system feeder at RAPS-2.

6.1.5 IAEA OSART Peer Review of Rajasthan Atomic Power Station -3&4

RAPS-3&4 underwent an IAEA OSART mission during October 29 to November 15, 2012. This was followed by an OSART follow-up mission in February 2014. The follow-up mission observed that of the 7 recommendations and 7 suggestions, 79% of the actions were completed, while there was satisfactory progress on the remaining 21% actions. The OSART follow-up mission appreciated the progress on implementation of the identified actions in short duration.

6.1.6 Light water reactors at Kudankulam

Two units of 1000 MWe LWRs (VVER based design) have been built at Kudankulam (KKNPP-1&2) in Tamil Nadu, with the co-operation of Russian Federation. The KKNPP-1 achieved first criticality in July, 2013 and is currently operational. The unit achieved its rated capacity on June 7, 2014 after satisfactory completion of all the requisite commissioning tests. The unit had its first refuelling outage from June 24, 2015 to January 21, 2016. During the outage, extensive inspections were carried out on a number of equipment / components for generating base-line data. The refuelling outage lasted for an extended duration owing to investigation and rectification of a rope failure in the fuelling machine, which required requalification of the fuelling machine. The shutdown was utilised to investigate and rectify the tube leaks in one of the steam generators. Further, modifications were implemented in the components of the reactor coolant pumps based on feedback from commissioning experience of KKNPP-2.

The KKNPP-2 achieved criticality on July 10, 2016 and unit is in advanced stage of commissioning for power operation.

6.2 SIGNIFICANT EVENTS

The technical specifications for operation of NPPs specify the criteria for reporting of significant events. During the period 2013 to 2015, 111 significant events were reported from 21 operating NPPs. All these significant events were reviewed both by the utility as well as AERB. Out of these, two events were rated at Level – 1 on IAEA – INES rating scale. The remaining events were rated at zero or below scale. Some of the events on which important lessons were learnt are described below.

6.2.1 Coolant channel leaks in KAPS-1&2

KAPS-2 experienced an incident of leak from one of its coolant channels on July 1, 2015, when it was operating at 203 MWe. The leak was indicated by increased level of moisture in the annulus gas monitoring system for the coolant channels. After the leak was detected, the unit was shut down, cooled and depressurized as per established operating procedure. Leaky coolant channel was subsequently identified through Annulus Gas Monitoring System (AGMS).

There was no radiation exposure to any plant personnel nor any radioactivity release to the environment during this event. The event was rated at Level – 0 in the INES.

KAPS-2 is the lead reactor in India employing coolant channels of Zirconium -2.5% Niobium (Zr-Nb) alloy. While the channels in KAPS-2 had seen operation of around 20 years, the Zr-Nb channels in other reactors have seen much lower operating lives.

In light of this event AERB carried out a thorough review of the coolant channels life management programme followed in NPCIL. AERB also mandated other operating NPPs to immediately conduct a performance check of the annulus gas monitoring systems as well as sensitise the operating staff to be vigilant about the trends of moisture in the annular gas monitoring system as during the initial stage of the incident, AGMS dew point did not reach alarm levels.

The investigation using the tool BARCIS confirmed existence of tight through wall crack near the rolled joint at the cold end of the leaky coolant channel. The failure mechanism was suspected to be similar to the failures typical of CANDU experience. BARCIS examinations covering rolled joint area were conducted on many other channels in the reactor to assess their health. No abnormality was observed. As part of investigation, the leaked channel in KAPS unit-2 was removed from the reactor for failure analysis. In Post Irradiation Examination, in addition to the through wall crack, presence of localized corrosion spots was also observed on the outer surface of this channel. In view of this observation, another channel from the same zone of the reactor was removed for examination. Similar corrosion spots were noticed on this channel also.

It was suspected that the prolonged exposure to steam environment provided by the leaky channel could have led to the localized corrosion. In view of such observations, BARCIS tool was tuned to detect presence of localized corrosion on outer surface of coolant channels.

While these investigations on the failure and aspects related to the ageing of coolant channel were in progress, on March 11, 2016 the KAPS-1, which had seen operation of less than 5 years since its en-masse coolant channel replacement, experienced an event of failure of a coolant channel. Following the leak from primary coolant system, the reactor underwent an automatic shutdown. The safety systems, viz emergency core cooling and containment isolation got actuated and performed as intended. Following the event, plant emergency was declared, which was terminated after safely discharging the fuel from the leaky channel and isolating this channel from the primary coolant system on March 21, 2016. There was no fuel failure.

The event did not result in any radiation over-exposure to plant personnel. The radioactivity releases were within the specified limits for normal operation. During the course of the plant emergency, the environmental surveillance carried out within the site as well as in the off-site domain up to 30-km from the plant confirmed that there was no increase in the background radiation levels and there was no radioactive contamination.

The event of KAPS-1 was rated at Level -1 (provisional) on INES.

The inspection of the failed channel with BARCIS indicated the presence of three through wall longitudinal cracks, along with corrosion spots on outer surface. The work for removal of failed channel for failure analysis is in progress.

The failure of coolant channel in KAPS-1 occurred at an early stage of its life.. Considering this and the observation of unprecedented localized corrosion spots on the exterior of the coolant channels in KAPS, expeditious inspection of coolant channels in all other operating reactors was undertaken to assess the health of the channels. No abnormality was observed. A thorough review of design and leak detection capability of AGMS in all other NPPs was also carried out.

6.2.2 Leak from primary coolant system at RAPS-2

On January 29, 2016, an incident of heavy water coolant leak from feeder pipe of one out of 306 coolant channels occurred at RAPS-2, while the unit was in the start-up process and the primary heat transport (PHT) system was being heated up. The incident did not result in release of radioactivity or over exposure to any worker. The leak occurred near a weld joint in the feeder stub. The PHT system was depressurised and clamps were installed to arrest the leak. As the affected portion of the feeder was in the non-isolable part of the reactor coolant system, it required draining of headers for its replacement. The affected portion of the feeder was replaced subsequently. The affected weld joint of the PHT system was made in early 1970s and was not part of the en-masse feeder replacement campaign carried out in the unit in 2007-08. In order to evaluate whether the failure was due to any generic cause, the weld joints at similar location of feeders of a number of other coolant channels were also inspected and no abnormality was found.

Taking note of this experience, the in-service inspection requirements for the PHT system feeders in all PHWR NPPs was augmented for enhanced coverage of such welds.

6.2.3 Inadvertent release of tritium activity to storm water drain at NAPS in June 2013

In June 2013, tritium activity (maximum 22.53 Bq/ml) was observed in water samples collected from a storm drain at NAPS. This storm drain was outside the dyke area of downgraded heavy water storage tanks located in the upgrading plant. At NAPS, a provision exists for transferring water from mobile tanker to the downgraded heavy water storage tanks in the upgrading plant. On three occasions, while the transfer pump did not work, the operator took steps to transfer downgraded heavy water (isotopic purity-0.4%; tritium concentration-3.6 MBq/ml) from tanker through the sump in the dyke area, in the absence of procedure for the same. While doing so, an inventory of about 100 litres active water was inadvertently left behind in the sump. In June 2013, the sump got flooded with rain water and overflowed leading to spread of the active water on the dyke floor. The valve in the dyke floor drain was partially open and the blind flange in the floor drain was passing due to deteriorated gasket condition. As a result, the active water leaked out from the dyke floor area and found its way to a nearby storm drain. About 0.37 TBq of tritium activity got released to the storm water drain due to this event as estimated. The event was rated at level 1 on INES.

Following this event the plant prepared a procedure for transfer of the liquid radioactive waste from mobile tanker to downgraded heavy water storage tanks. The plant has also enhanced the surveillance and preventive maintenance of the barriers (isolation valves, blind flanges etc.) in the liquid waste system.

6.2.4 Inadvertent Radiation exposure of radiation worker at TAPS-3&4 on May 17, 2014

On May 17, 2014, a SPND canister containing irradiated neutron detectors was picked from the spent fuel storage bay by energising an electromagnet (attached to a hoist) for shifting inside a transportation flask at TAPS- 4. While lowering this electromagnet, along with the SPND canister inside the transportation flask, the canister body got disengaged from its top cover plate due to failure of screws and fell into the transportation flask. The top cover of the canister remained attached to the electromagnet. While the operator noticed the dropping of the canister through a camera monitor, he misinterpreted it as the result of de-energization of the electromagnet, though he had actually not carried out the step of de-energization. Subsequently , when the electromagnet was retracted, the canister top cover plate (with cobalt contamination) got unshielded causing high radiation field in the working area. This was detected by local radiation monitors and the area was immediately evacuated. However, a worker present in that area received radiation dose of 15.7 mSv. The event resulted in his dose reaching 17.36 mSv for year 2014. The event revealed shortfalls in the procedure for transfer of irradiated neutron detectors and the effective implementation of human error prevention tools like self-check, peer check, supervision. The event was reviewed in detail by the utility and AERB. Further transfer of irradiated neutron detectors was permitted only after satisfactory implementation of the necessary corrective actions by the plant to prevent occurrence of such event in future. The event was rated at level 1 on INES.

6.3 PERIODIC SAFETY REVIEW

Periodic Safety Reviews (PSR) of the nuclear power plants are carried out as a regulatory requirement for renewal of license for operation of NPP. The first round of PSR for all the NPPs has been completed. For NPP of new design the first PSR is required to be carried out after five years of initial operation and accordingly, the PSR of TAPS-3&4 (540 MWe) was completed after five years of commercial operation.

Safety assessments performed during PSR take into account current regulatory requirements, safety standards and operating practices. It also considers factors such as cumulative effects of plant ageing& obsolescence, modifications, feedback of operating experience, safety analysis and development in science and technology. Through this process of PSR, the strengths and shortcomings of the NPP against the requirements of current standards are identified. The report on the PSR prepared by NPP is subjected to regulatory review for satisfactory resolution of the identified issues.

In the last three years PSR was carried out for three NPPs (TAPS-1&2, KAPS-1&2, MAPS-1&2). During these PSRs the upgrades necessary for safety enhancement taking into considerations Fukushima accident were also reviewed and the long term actions for safety enhancements are drawn and being followed up.

6.4 OPERATIONAL EXPERIENCE FEEDBACK PROGRAMME

Utility and AERB have established structured programme for reviewing external as well as internal OE pertaining to operating NPPs. The programme includes systematic collection of information, screening, review, dissemination and finally monitoring the implementation of the review recommendations.

For reviewing international operating experience at AERB, IRS reports received are screened and a group of experts review the screened reports. To implement a graded approach in operating experience utilization, screening guidelines have been developed. Review reports are prepared encapsulating the highlights. Events which demand further review are selected for discussion in a high level review group, OERG. These information and feedbacks are used by the AERB officers during regulatory inspections and safety review process. The lessons learnt for safety enhancements in NPPs and improvement of regulatory practices are implemented in core regulatory activities for meeting the complete intent of OE.

6.5 SAFETY ENHANCEMENTS OF OPERATING NPPs

Right from the early stages of nuclear power programme in India, emphasis has been placed on learning lessons from the operating experience and utilizing it to enhance the safety of NPPs. A structured mechanism for safety reviews within the utility and the regulatory body has evolved over a period of time.

With an active nuclear power programme, the designs of NPPs have been seeing enhancements over time, particularly in respect of safety, in tune with the prevailing international benchmarks and best practices. This has facilitated the Indian NPP design approach to stay up to date with the state of art.

India has a robust operating experience feedback programme through which the important events / developments and their implications with respect to safety of NPPs are reviewed for identifying the need for any safety enhancements in the existing plants and / or the design of new NPPs. Special safety reviews were undertaken following major events like Three Mile Island accident of 1979, the Chernobyl accident of 1986, the fire incident at Narora Atomic Power Station (NAPS) in 1993, the flood incident at the Kakrapar Atomic Power Station (KAPS) in 1994, the tsunami at the Madras Atomic Power Station (MAPS) in 2004, the Fukushima accident in 2011, and pressure tube leaks at KAPS in 2015-16.

India has adopted the Periodic Safety Review (PSR) process involving comparison with the current safety requirements / practices. PSR is carried out once in ten years and is one of the basis for renewal of operating license which ensures that safety upgrades identified are implemented in a timely manner.

While the older NPPs have seen maximum of these upgrades, the plants built subsequently have incorporated these features as part of the design. The examples of safety enhancements in Indian NPPs based on the above reviews are as follows:

- Enhancement of emergency power supplies with specific emphasis to avoid common cause failures
- Fire protection measures: augmentation of fire detection systems, cable segregation, and fire localisation measures
- Dedicated instrument air supply to critical valves within the containment and isolating other inputs of air supply with the objective of maintaining functionality while minimizing post-accident over pressurisation of containment
- Diesel engine driven fire water pumps
- On-site water storage and provision for injection from (diesel driven) fire water pumps as back-up emergency water supply to SGs and ECCS through independent line
- Enhancing the redundancy of off-site power
- Supplementary control room (SCR) : Incorporating where the SCRs were not existing and enhancing the functionality including back-up power supply
- Unit-wise segregation of shared safety and safety related systems
- Revision of safety analysis using state of the art analytical tools, taking account of current configuration
- Systematic programmes for Ageing Management and Equipment Qualification
- Seismic re-evaluation of old plants and consequent strengthening of SSCs, where necessary

- Reassessment of flood levels at existing sites considering upstream dam failure for in-land sites and tsunami hazard at coastal sites resulting in implementation of improvements at places such as
    - Installation of additional DGs at higher elevation
    - Additional air compressors at higher elevation
    - Providing protection for safety critical equipment in potential wet areas
- Consideration of station blackout as part of design which calls for provision of passive poison injection to moderator system to achieve long term sub-criticality in PHWRs,
- Onsite storage of fuel for EDG and water for 7 days cooling requirement.

As brought out above, substantial safety enhancements were made in the past in the existing NPPs and the design of new NPPs. The safety reviews carried out following the Fukushima accident also corroborated the inherent strengths in the design, operational and regulatory practices and requirements associated with the Indian NPPs. The post Fukushima strengthening measures identified and being implemented for the Indian NPPs are associated mainly with enhancing the resilience of the plants to cope with extreme external events exceeding the design bases and to strengthen the provisions for mitigation of severe accidents. The specific enhancements following Fukushima accident based on safety review conducted in Indian NPPs were presented in detail in the National Reports to the 2nd Extraordinary Meeting (2012) and the 6th Review Meeting of CNS. These are summarised below:

- Short term measures
    - External hook up points for addition of water to important reactor systems and spent fuel bay
    - Additional emergency lighting backed up by solar cells
    - Review and revision of Emergency Operating Procedures
    - Training and mock-up exercises of operating personnel
- Medium term measures
    - Introduction of automatic seismic trip where it does not exist
    - Provision of additional backup DGs (air cooled mobile/fixed) at higher elevation
    - Strengthening provision for monitoring of critical parameter under prolonged loss of power
    - Provision of diesel driven pumps for transfer of water from deaerator storage tank to steam generators
    - Additional mobile pumps and fire tenders
    - Steps for seismically strengthening and further augmentation of onsite water storage, wherever required
- Long term measures
    - Enhancing Severe Accident Management programme
    - Strengthening hydrogen management provisions
    - Provision for filtered venting of containment
    - Creation of on-site emergency support centre capable of withstanding extreme flood, cyclone & earthquake etc.

The system established for conducting systematic and regular reviews and the safety enhancements, as brought out above, is consistent with the Vienna Declaration on Nuclear Safety with respect to the existing NPPs.

6.5.1 Status of implementation of post Fukushima safety enhancements

AERB is closely monitoring the progress of safety enhancements of operating NPPs. As of now, implementation of the short term and medium term enhancements have been completed in all the NPPs. The status of long term enhancements is as below:

i. Enhancing severe accident management programme

The Generic Technical Basis Document (TBD) on 'Accident Management Guidelines (AMGs)' for Indian PHWRs has been reviewed by AERB. Based on this generic document, station specific accident management guidelines have been prepared and reviewed by an expert group of NPCIL. The enhanced AMGs for TAPS-1&2 (BWR units) is presently being reviewed in AERB. The station specific Accident Management Guidelines are now in place at all stations and personnel have been trained.

ii. Strengthening hydrogen management provisions

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

iii. Provision of containment filtered venting

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

iv. Creation of on-site emergency support centre

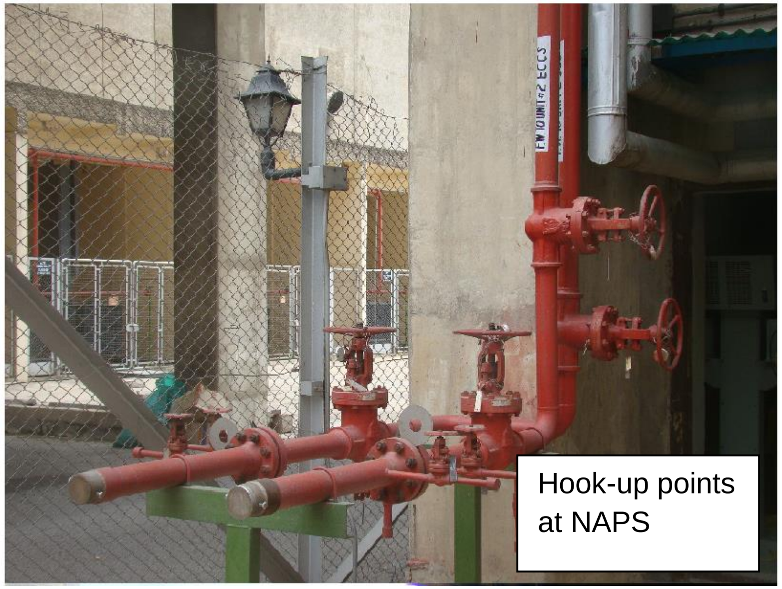
AERB has framed requirements and guidelines for establishing On-Site Emergency Support Centers (OESCs) at all NPPs. This facility should have capability to remain functional under radiological conditions following a severe accident and should be capable of withstanding extreme external events (flood,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

6. 6 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

Since the inception of the atomic energy programme in the country, priority has been given to the adoption and maintenance of high safety standards. Safety status of the NPPs is continually monitored by an established system. India follows a periodic safety review (PSR) programme which forms one of the basis for renewal of operating licenses of NPPs. Replacements or modifications of the structures, systems and components important to safety are carried out as necessary. Enhancements are also carried out to resolve obsolescence issues. Robust programme exists for feedback of operating experience for learning lessons and to take timely actions to enhance safety. A system exists for comprehensive and systematic safety reviews of NPPs to be conducted regularly and periodically throughout their lifetime. Based on these reviews, safety enhancements are identified and implemented. These systems ensure that India complies with the obligations of Article 6 of the Convention as well as the principles of the Vienna Declaration on Nuclear Safety.

Annex 6-1: Photographs on safety up-gradations in NPPs

Hook-up points at RAPS-3&4



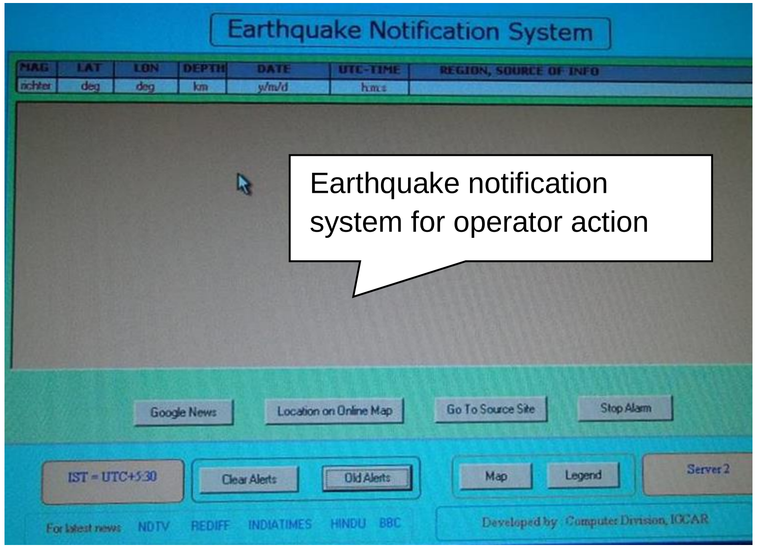
Hook-up points at NAPS

Hook-up points at KGS-1&2

Mock exercise for checking adequacy of mobile pump with the hookup points at KGS-1&2

Foundation of SBO DG and starting batteries elevated

Foundation of Cooling Tower and pumps of SBO DG elevated



Earthquake notification system for operator action

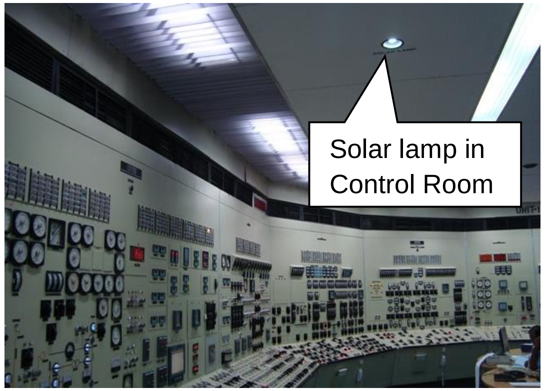
Seismic system annunciator to alert operator

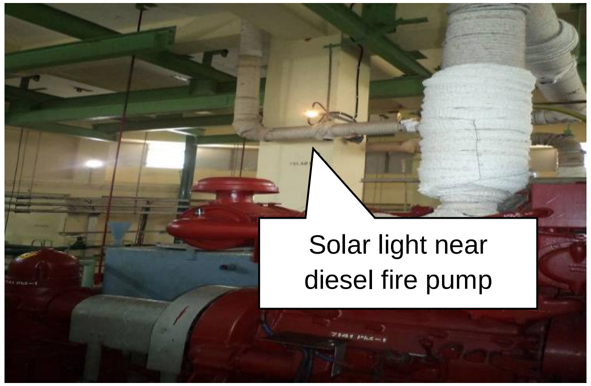
Safety Upgrades at TAPS-1&2

Diesel Generator Power

Fire tender at NAPS

Provision of Alternate Power Supply and Water Source for BDBA





Provision of solar lighting

ARTICLE 7: LEGISLATIVE AND REGULATORY FRAMEWORK

1. **Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations.**
2. **The legislative and regulatory framework shall provide for:**
   i. **the establishment of applicable national safety requirements and regulations;**
   ii. **a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a licence:**
   iii. **a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of licences;**
   iv. **the enforcement of applicable regulations and of the terms of licences, including suspension, modification or revocation.**

7.0 GENERAL

India is a Union of States. It is a Sovereign Socialist, Secular and Democratic Republic. The Constitution of India provides for a Parliamentary system of government which is federal in structure. The Constitution distributes legislative powers between the Parliament and the State Legislatures as per the lists of entries in the Seventh Schedule of the Constitution. The subject 'atomic energy and the mineral resources necessary for its production' are placed in the union list. Accordingly, the laws pertaining to atomic energy are enacted by the Parliament and enforced by the Central Government.

7.1 ESTABLISHING AND MAINTAINING LEGISLATIVE AND REGULATORY FRAMEWORK

The legal framework for atomic energy was established in India in the year 1948 and legislation by the name Atomic Energy Act, 1948 was enacted. The Atomic Energy Act, 1948 was repealed and the Atomic Energy Act 1962 was enacted subsequently. The Atomic Energy Act 1962 provides for the development, control and use of atomic energy for the welfare of the people of India and for other peaceful purposes. Atomic Energy Act 1962 and rules framed thereunder provide the main legislative and regulatory framework pertaining to atomic energy in the country. The Act provides the Central Government with the powers to frame rules and issue notifications to implement the provisions of the Act. The Rules framed under the Act are laid on the floor of both the houses of the Parliament.

In addition to the provisions of the Atomic Energy Act, the provisions of several other legislations related to environment, land use, etc. have also to be met for locating and operating Nuclear Power Plants (NPPs). The provisions of these Acts are enforced by Central or State Government, as the case may be. Important legislations that have a bearing on the establishment and operation of NPPs are summarised below:

7.1.1 Atomic Energy Act 1962

The following paragraphs briefly describe the salient provisions of this Act.

i. Powers of the Central Government in the domain of atomic energy

Section 3 of the Act describes the powers of Central Government in the domain of atomic energy including the powers (i) to produce, develop, use and dispose of atomic energy; (ii) to provide for the production and supply of electricity from atomic energy, (iii) to provide for control over radioactive substances or radiation generating plant in order to (a) prevent radiation hazards; (b) secure safety of public and plant personnel and (c) ensure safe disposal of radioactive wastes; etc. The Central Government is also empowered to fulfil the responsibilities assigned by the Act either by itself or through any authority or Corporation established by it or a Government company.

ii. *Control over Mining or Concentration of Prescribed Substances*

Section 4 to section 13 of the Act gives wide-ranging authority to the Central Government for harnessing and securing the prescribed substances useful for atomic energy.

iii. *Control over production and use of atomic energy*

Section 14 of the Act gives the Central Government control over production and use of atomic energy and prohibits these activities except under a licence granted by it. Subsection 2 of this section gives the Central Government powers to refuse licence or put conditions as it deems fit or revoke the licence. Sub section 3 of this section of the Act also gives the Central Government powers to frame rules to specify the licensees the provisions in the areas of:

a. control on information and access,
b. measures necessary for protection against radiation and disposal of by-products or wastes
c. the extent of the licensee's liability and
d. the provisions by licensee to meet obligations of the liability either by insurance or by such other means as the Central Government may approve of.

iv. *Control over radioactive substances*

Section 16 of the Act gives the Central Government power to prohibit the manufacture, possession, use, transfer by sale or otherwise, export and import and in an emergency, transport and disposal, of any radioactive substances without its written consent.

v. *Special Provisions as to safety*

Section 17 of the Act empowers the Central Government to frame rules to be followed in places or premises in which radioactive substances are manufactured, produced, mined, treated, stored or used or any radiation generating plant, equipment or appliance is used. This section gives the Central Government authority to make rules to prevent injury being caused to the health of the persons engaged or other persons, caused by the transport of radioactive or prescribed substances and to impose requirements, prohibitions and restrictions on employers, employee and other persons. It also gives the Central Government authority to inspect any premises, or any vehicle, vessel or aircraft and take enforcement action for any contravention of the rules made under this section.

vi. *Special provisions as to electricity*

Section 22 of the Act gives the Central Government the authority to develop national policy for atomic power and coordinate with national & state authorities concerned with control and utilization of other power resources for electricity generation to implement the policy. It authorizes the Central Government to fulfil the mandate either by itself or through any authority or corporation established by it or a Government Company.

vii. *Administering Factories Act, 1948*

Section 23 gives the Central Government authority to administer the Factories Act, 1948 to enforce its provisions by framing rules and appointment of inspection staff in relations to any factory owned by the Central Government or any Government Company engaged in carrying out the purposes of the Act.

viii. *Offences and Penalties*

Section 24 of the Act gives provision for imposing penalties. Whoever contravenes any order or any provision of the Act shall be punishable prosecution with imprisonment, or with fine, or both.

ix. Delegation of powers

Section 27 of the Act gives the provision for the Central Government to delegate any power conferred or any duty imposed on it by this Act to any officer or authority subordinate to the Central Government, or state government, as specified in the direction.

x. Power to make rules

Section 30 of the Act gives the provisions for the Central Government to frame rules for carrying out the purposes of the Act.

Amendments in the Atomic Energy Act 1962

The Atomic Energy Act 1962 has seen three amendments so far. The first amendment was effected in December 1986 for amending section 6 of the Act and to introduce a new section 11a in the Act which dealt with the issue of acquisition of Uranium. The second amendment was effected in September 1987, with amendments in sections 2, 3 and 22 of the Act. This amendment was to facilitate a government company and/or authority or corporation of the government to conduct the activities related to production, development, use and disposal, of atomic energy. The third amendment was effected in December 2015, to re-define a Government Company and to specify certain specific aspects related to granting licenses under Section 14 of the Act to such companies.

7.1.2 Indian Electricity Act 2003

Indian Electricity Act, 2003, consolidates the laws relating to generation, transmission, distribution, trading and use of electricity and generally for taking measures conducive to development of electricity industry. The Act prohibits any person from transmission or distribution or trading in electricity unless he is authorised to do so by a licence issued under section 14, or is exempt under section 13 of the Act.

7.1.3 Environment (Protection) Act 1986

The Environment Protection Act, 1986 provides for the protection and improvement of environment and matter connected therewith. All projects or activities, including expansion and modernization of existing projects or activities, require prior environmental clearance from the Central Government in the Ministry of Environment, Forests and Climate Change (MoEFCC) on the recommendations of an Expert Appraisal Committee (EAC).

7.1.4 Factories Act 1948

The Factories Act is a social legislation which has been enacted for occupational safety, health and welfare of workers at work places. The administration of the provisions of the Factories Act 1948, in the units of Department of Atomic Energy (DAE) is done through Atomic Energy (Factories) Rules, 1996, as per the provisions in Section 23 of Atomic Energy Act.

7.1.5 The Disaster Management Act, 2005

The Disaster Management Act, 2005 provides for effective management of disasters including accidents involving NPPs. As per the provisions of the Act, the National Disaster Management Authority (NDMA) has been established. The NDMA has the responsibility for laying down policies, plans and guidelines for disaster management for ensuring timely and effective response to any disaster including radiological/nuclear disasters.

7.1.6 Other Applicable Legislations

The other applicable legislations for locating and operating NPPs in the country include:

i. The Water (Prevention & Control of Pollution) Act, 1974

ii. The Air (Prevention & Control of Pollution) Act, 1981

iii. The Water (Prevention & Control of Pollution) Cess Act, 1977

iv. The Indian Explosive Act 1884, and Indian Explosive Rule, 1983

v. The Indian Boilers Act, 1923

vi. The Civil Liability for Nuclear Damage Act, 2010

7.1.7 International Conventions related to Nuclear Safety

India has ratified the following international conventions:

i. Convention on Early Notification of a Nuclear Accident
ii. Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency
iii. Convention on the Physical Protection of Nuclear Material
iv. Convention for Suppression of Acts of Nuclear Terrorism
v. Convention on Nuclear Safety
vi. Convention on Supplementary Compensation for Nuclear Damage

7.2 PROVISIONS OF LEGISLATIVE AND REGULATORY FRAMEWORK

7.2.1 National Safety Requirements and Regulations

7.2.1.1 Subordinate Legislation for Nuclear safety

The National Legislative requirement on nuclear and radiological safety for all activities related to atomic energy program and the use of ionising radiation in India is provided by Sections 3 (e) (i), (ii) and (iii), 16, 17 and 23 of the Atomic Energy Act, 1962. Also, exercising powers under section 30 of the Act, the Central Government has framed rules to implement the provisions of the Act which are subordinate legislation for regulation. These cover radiological safety, management of radioactive wastes, administration of Factories Act and prescription of qualifications of persons employed in installations dealing with radioactive substances or use of any radiation generating plant, equipment or appliance.

I. Rules Framed under the Atomic Energy Act, 1962

Under the Atomic Energy Act 1962, the Central Government promulgated the following rules:

i. Atomic Energy (Radiation Protection) Rules 2004, GSR 1691: These rules give requirement of consent for carrying out any activities for nuclear fuel cycle facilities and use of radiation for the purpose of industry, research, medicine, etc.

ii. Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987, GSR 125: establishes the requirements for the disposal of radioactive waste in the country.

iii. Atomic Energy (Working of the Mines, Minerals and Handling of Prescribed Substances) Rules, 1984, GSR 781. These rules regulate the activities pertaining to mining, milling, processing and/or handling of prescribed substance.

iv. Atomic Energy (Arbitration Procedure) Rules, 1983: These rules were framed to regulate arbitration procedure for determining compensation.

Atomic Energy Regulatory Board (AERB) was established in 1983 under the provisions of the Atomic Energy Act 1962. AERB is the national regulatory body having powers to frame safety policies, lay down safety standards & requirements and powers to monitor & enforce provisions under the Act and rules thereof, in nuclear and radiation installations and practices.

To further strengthen the legal framework for safety regulation of safety in nuclear facilities as well as radiation facilities and associated activities, Government had introduced the ‘Nuclear Safety Regulatory Authority (NSRA) Bill 2011’ in the Parliament in the year 2011. The Bill aimed to establish the regulatory body under the new legislation. However, the term of the Lok Sabha (Lower House) expired before the bill could be taken up. A similar bill is being processed with a view for introduction in the current term of the Parliament.

II. Atomic Energy (Factories) Rules, 1996

The Central Government exercising the powers conferred by sections 41, 49, 50, 76, 83, 112 and all other enabling sections of the Factories Act, 1948, read with sections 23 and 30 of the Atomic Energy Act, 1962, had framed the Atomic Energy (Factories) Rules, 1984 to administer the requirement of Factories Act in the nuclear establishments to ensure industrial safety. These rules were revised in 1996 and superseded by Atomic Energy (Factories) Rules 1996 GSR 253. (The Gazette of India Part II Sec 3(i) June 22, 1996)

III. Rules arising from other Legislations

In addition to above, the safety requirements of other applicable legislations also need to be met for establishing and operating NPPs in India. The central or state agencies, as the case may be, have been identified to regulate the safety provisions of these acts and the applicants are required to obtain necessary clearances from these agencies. Some of the important applicable legislations are mentioned here.

i. Environment Protection Act,1986, and Environment (Protection) Rules,1986, which provides safety requirement and regulation for the protection of environment, requires prior environmental clearance from Central Ministry of Environment, Forests and Climate Change (MoEFCC) for establishing nuclear power stations. Public hearing is conducted as per the ‘procedure for conduct of public hearing’ given in the gazette notification from MoEFCC. The hearing is conducted on the environmental and social impact of the nuclear power station. The hearing allows public to express its views and receive answers to its questions.

ii. The Pollution Control Boards (PCB), ensure implementation of the following legislations related to the protection of the environment in the country.

   a. The Water (Prevention & Control of Pollution) Act, 1974

   b. The Air (Prevention & Control of Pollution) Act, 1981

   c. The Water (Prevention & Control of Pollution) Cess Act, 1977

   d. The Hazardous Waste (Management, Handling and Transboundary Movement), Rules 2008.

iii. The Indian Electricity Act, 2003 and Indian Electricity Rules, 2005 covering various aspects of electrical safety also apply to NPPs. The Electricity Inspector of Electricity Board of the concerned state is designated as the authority to implement the provisions of these Acts & Rules.

iv. The Indian Boilers Act, 1923 also applies to the boilers used at NPPs and the authority to implement the provision of this act vests with the Boiler Inspector of the state under which the plant is located.

v. Indian Explosives Act 1884 and Indian Explosives Rules 1983 provide the Central Government power to prohibit manufacture, possess, use, sale, transport of explosives except under a licence granted by it. The Directorate of Explosives regulates the provision of this Act and the rules for use and storage of materials such as Diesel, Chlorine, compressed air, fuel oil etc.

vi. Civil Liability for Nuclear Damage Rules 2011

vii. Nuclear Liability Fund Rules, 2015

Annex 7-1 gives a list of the important legislations and the agencies identified to regulate them.

7.2.1.2 AERB Safety Codes and Guides

One of the mandates of AERB is to formulate safety requirements for nuclear and radiation facilities. For NPPs, AERB has issued Safety Codes for Regulation, Site Evaluation, Design, Operation, Radiation Protection, Radiation Waste Management and Quality Assurance and several safety guides and manuals under these Codes. Safety codes establish objectives and specify minimum requirements that have to be fulfilled to provide adequate assurance for safety in nuclear and radiation facilities. The Atomic Energy (Radiation Protection) Rules, 2004, provides the Competent Authority, the legal powers for issuing the codes and to enforce the requirements. Safety Guides provide guidelines and indicate methods for implementing specific requirements prescribed in the Codes. In addition to these, AERB also issues Safety Manuals which elaborate specific aspects and contain detailed technical information and procedures.

During the preparation of these documents, the safety requirements recommended by IAEA and the regulatory agencies of other countries are also considered. The safety documents are reviewed and updated periodically based on experience and scientific developments and to harmonize these with the recommended current safety standards of IAEA.

AERB has issued safety directives on dose limits for radiation workers and members of public which are in line with the recommendation of the International Commission on Radiological Protection (ICRP).

7.2.1.3 Process of Developing and Revising Safety Codes and Guides

As mentioned above, one of the mandates of AERB is to develop safety codes and guides for regulation of nuclear and radiation facilities. The need for development / revision of a safety document is identified by the various Divisions of AERB. Having identified the document to be prepared / revised, a Safety Document Development Proposal (SDDP) is prepared and circulated within AERB for comments. The SDDP is reviewed by advisory committees for development of safety documents as applicable (please refer section 8.1.2.2 and 8.1.2.4 in Article 8). The SDDP of the document for NPPs is further reviewed by Advisory Committee on Nuclear Safety (ACNS) and is finally approved by Chairman, AERB. The SDDP for safety codes is approved by the Board of AERB. Based on the SDDP, the draft of the document is prepared by a working group constituted for the purpose. While preparing the document, provisions of relevant IAEA standards are taken into account as appropriate. The document is reviewed and approved following the same procedure as for the SDDP.

AERB follows a system of "multi-tier committees" to prepare safety documents. The system ensures that the documents are based on expert opinion and are unbiased. The specialists from AERB, user organisations, technical institutions like Indian Institutes of Technology, national research laboratories and universities are members in the various committees.

India has now formally introduced a mechanism for obtaining and addressing comments from members of public on the safety codes under development. This mechanism has enabled public participation in framing of safety requirements.

7.2.2 System of Licensing

7.2.2.1 Requirements and Legal Provisions of Licensing under the Atomic Energy Act

As per the provisions of the Atomic Energy Act, 1962, in India, only the Central Government; or any authority or corporation established by it; or a Government Company can be allowed to establish and operate a Nuclear Power Plant. Section 14 of the Act specifies the requirement of obtaining licence from the Central government for production and use of atomic energy. Section 16 of the Act prohibits the manufacture, possession, use, transfer by sale or otherwise, export and import and in an emergency, transport and disposal, of any radioactive substances without obtaining the consent of the Central government. Further, Section 17 of the Act gives the Central Government power to prescribe the requirement for safety and waste management.

The Competent Authority issues the Regulatory Consent / Licence in accordance with the provisions of the Section 16 and 17 of the Atomic Energy Act, 1962 and the Rule 3 of the Radiation Protection Rules, 2004. Rule 3 of the RPR 2004, prescribes that a licence from the Competent Authority is necessary for handling any radioactive substance. Rule 3 of the Atomic

Energy (Safe Disposal of Radioactive Wastes) Rules 1987, stipulates that an Authorisation from the Competent Authority is required for disposal or transfer of radioactive wastes. Rule 4 of Atomic Energy (Factories) Rules 1996 prescribes that 'Approval' of the Competent Authority shall be obtained for using any premises as a factory for purposes of the Atomic Energy Act 1962. Chairman, AERB is the Competent Authority designated by the Central Government for issuing consents/licenses as applicable under the above said rules. For NPPs, the consents are issued for the major stages like Siting, Construction, Commissioning and Decommissioning and license is issued for Operation.

AERB safety code of 'Regulation of Nuclear and Radiation facilities (AERB/SC/G: 2000)' specifies the minimum safety related requirements/obligations to be met by a nuclear or radiation facility to qualify for the issue of regulatory consent / license at every stage during the life cycle of an NPP. The code also elaborates on regulatory inspection and enforcement to be carried out by the Regulatory body in such facilities.

After the issuance of license for operation, renewal of license is based on comprehensive safety review once in five years and conduct of PSR, once in 10 years. AERB carries out continual safety supervision by way of reporting obligations, regulatory inspections & enforcements. AERB adopts a multi-tier review and assessment process for new projects and operating NPPs. Annex 7-2 typically indicates various regulatory documents issued by AERB pursuant to primary legislations pertaining to atomic energy in India.

The detailed consenting/licensing process in India is described in chapter on Article 14 (Assessment and Verification of Safety).

7.2.2.2 Consenting Process for Nuclear Power Plants

AERB safety code on 'Regulation of Nuclear and Radiation Facilities AERB/SC/G: 2000' gives the mandatory requirements/obligations to be met by a nuclear or radiation facility, to qualify for the issue of regulatory consent/license. The Safety Guide "Consenting Process for Nuclear Power Plants and Research Reactors" AERB/NPP&RR/SG/G-1:2007 defines the regulatory consenting process for all the major stages of a nuclear power plant/research reactor. It covers in detail the information required to be included in the submissions to AERB, mode of document submissions and their classification, and areas of review and assessment for issuing the regulatory consent. The major stages of consenting process for NPPs/Research Reactors are Siting, Construction, Commissioning, Operation and Decommissioning. As per the provision of the guide, AERB may also consider pre-licensing safety review.

Safety in siting, design, construction, commissioning and operation of the facilities is ensured primarily through regulatory actions including issuance of consent/license for activities and imposition of conditions on the applicant. AERB performs these actions on the basis of its review and assessment. In general, a three-tier review process is followed by AERB before any major activity concerning NPP, issued consent. In certain cases AERB may opt for alternative review process as deemed necessary.

7.2.3 System of Regulatory Inspection and Assessment

Regulatory Inspection is one of the responsibilities and functions of AERB. The Regulatory inspection and assessment process ensures:

i. compliance with the safety provisions of the primary and subordinate legislations and other consenting conditions;

ii. that nuclear facilities are sited, constructed, commissioned and operated in conformity with design intent duly approved by AERB;

iii. that safety-related structures, components and systems are of approved quality based on acceptable standards; and

iv. facilities operate within the approved Technical Specifications for Operation and the respective operating personnel are competent to operate the facility safely.

7.2.3.1 Legal Provision for Regulatory Inspection

Section 8 of the Atomic Energy Act gives the Central Government powers to enter and inspect any mine, premises and land for the purpose of the Act. For the purpose of safety, subsections 4 and 5 of Section 17 of the Act gives the Central Government powers to inspect any premises, vehicle, vessel or aircraft and take enforcement actions to prevent any contravention of the rules framed under the provision of this section. The provisions of Atomic Energy (Radiation Protection) Rules 2004, Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 and Atomic Energy (Factories) Rules, 1996 are also enforced by AERB. A system of regulatory inspection is established to verify compliance with the rules. The powers to inspect and take enforcement actions for industrial safety are drawn from the provisions of section 8 & 9 of the Factories Act 1948. AERB Safety Code on Regulation of Nuclear and Radiation facilities AERB/SC/G: 2000 and safety guides and manuals issued thereunder provide the details regarding the system of regulatory inspection and enforcement.

Other governmental bodies like PCB, MoEFCC also carry out inspection from time to time for enforcement of the requirements relating to conventional pollutants, environmental aspects etc.

7.2.3.2 Inspection Strategies and Assessment Method

The regulatory inspection strategies are comprehensive and developed to ensure that NPPs comply with the regulatory requirements. Inspections are carried out as per the specified frequency during all stages of consenting process. The frequency as well as the extent to which inspection is performed depends upon the significance of the consenting stages and sub-stages therein with respect to safety and potential, magnitude or nature of the hazard associated with the type of activity.

AERB undertakes inspection activities as per its inspection schedule or as warranted by any event. For all routine/planned regulatory inspections the areas and frequencies of inspection are specified. AERB also carries out surprise inspections.

Verification of overall safety performance also requires inspections that focus on a relatively broad range of subject areas, with adequate depth and frequency. Each planned inspection has specific objectives, which are identified in advance and informed to the plant management and the inspection personnel. On the other hand, during regulatory inspection following an event, specialists carry out an in-depth review of the areas relevant to the event.

The observations made during regulatory inspections are categorized according to their safety significance. Inspection findings and utility response are reviewed in AERB and enforcement actions as deemed necessary are taken.

7.2.3.3 Inspection Programme

Regulatory inspection programme of AERB is described in the safety guide “Regulatory Inspection and Enforcement in Nuclear and Radiation Facilities” AERB/SG/G-4. The inspection programme includes the following:

i. developing required procedures for the effective conduct and administration of the inspection programme;

ii. conducting, as necessary, planned inspections during all stages of the consenting process and throughout the service life of the NPP as well as on decommissioning;

iii. verifying the Consentee's compliance with the regulatory requirements and otherwise assuring continuous adherence to safety objectives;

iv. carrying out reactive inspections in response to events

v. documenting its inspection activities and findings;

The regulatory inspection includes planned, unannounced and reactive inspections. Inspections are carried out throughout the life cycle of a NPP. The inspections may include examinations of actual physical status of NPPs, various procedures, records and documents, surveillance tests, and interviews with the utility personnel as well as conduct of investigations, and collection of samples among others. The frequency and scope of regulatory inspections is reviewed as part of the internal review of regulatory practices and modified, if found necessary. AERB has been empowered to exercise the powers for entry and inspect the nuclear and radiation facilities, including the related designers, manufacturers and vendors.

7.2.4 Enforcement of Applicable Regulations and Terms of Licences

AERB has the necessary legislative powers to frame safety regulations, establish licensing conditions. It has also established regulatory mechanism to enforce them.

7.2.4.1 Legal Provision and Power for Enforcement

Subsections 4 and 5 of Section 17 (Special provisions as to safety) of the Atomic Energy Act give the Central Government powers to inspect and take enforcement actions to prevent any contravention of the rules. AERB has been identified as the Competent Authority to enforce the provisions of Atomic Energy (Radiation Protection) Rules 2004, Atomic Energy (Safe Disposal of Radioactive Wastes) Rules 1987 and Atomic Energy (Factories) Rules, 1996. AERB Code of practice 'Regulation of Nuclear and Radiation facilities AERB/SC/G: 2000' and safety guides issued under it provide the details regarding the system of enforcement.

7.2.4.2 Elements for Enforcement Actions

Several graded enforcement options are available to AERB to ensure that the consentee takes timely corrective actions. The actions taken are based on aspects such as safety significance of the deficiency, seriousness of violations, the repetitive nature and/or deliberate nature of the violations. Enforcement actions arise from review of documents submitted by the consentee or findings during review or inspection. The enforcement actions include one or more of the following:

i. a written directive for satisfactory rectification of the deficiency or deviation detected during inspection;

ii. written directive for improvement within a reasonable time frame;

iii. orders to curtail or stop activity;

iv. modification, suspension or revocation of operating consents; and

v. Initiating penal actions.

The enforcement measures taken by AERB during the past three years are brought out in chapter on Article 14 (Assessment and Verification of Safety).

7.3 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

Since the inception of the atomic energy programme in the country, an elaborate legislative and regulatory framework is in place. The national safety requirements pertaining to atomic energy emanate from the Atomic Energy Act, 1962 and rules issued thereunder. The Act and the Rules establish the basic national system of licensing, inspection and enforcement. Pursuant to the objectives identified in the system of licensing, AERB has laid down a comprehensive framework of safety requirements in various Safety Codes issued by it including Safety Code on Regulation of Nuclear and Radiation Facilities and several guides issued under the Code. These safety guides provide guidance on acceptable ways to adhere with safety requirements laid down in the Safety Codes. The Legislative and Regulatory framework in the country is comprehensive to harness the benefit of atomic energy in a safe and secured manner and dynamic enough to embrace the evolving aspirations. This enables India to comply with the obligations of Article 7 of the Convention.

Annex 7-1: National Safety Requirements and Regulation

Legislative & Regulatory Framework: Atomic Energy Act, 1962, Indian Electricity Act, 2003, Environment (Protection) Act, 1986, Factories Act, 1948, etc

National Safety Requirements & Regulations

REGULATORY AUTHORITY

AERB

- Atomic Energy Act, 1962
  - Atomic Energy (Radiation Protection) Rules, 2004
  - Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987
  - Atomic Energy (Working of the Mines, Minerals and Handling of Prescribed Substances) Rules, 1984
  - Atomic Energy (Factories) Rules, 1996
  - Regulatory Codes & Standards

MoEFCC

- Environment Protection Act, 1986
  - Environmental Protection (Amendment) Rules, 1987

PCB

- The Water (Prevention & Control of Pollution) Act, 1974
- The Air (Prevention & Control of Pollution) Act, 1981
- The Water (Prevention & Control of Pollution) Cess Act, 1977
  - The Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.

SEB

- Indian Electricity Act, 2003
- Indian Electricity Rules, 1956

SBI

- Indian Boilers Act, 1923

DoE

- Indian Explosives Act, 1884
  - Indian Explosives Rules, 1983

MHA

- Disaster Management Act, 2005

Legend

AERB: Atomic Energy Regulatory Board

MoEFCC: Ministry of Environment, Forests & Climate Change

PCB: Pollution Control Board

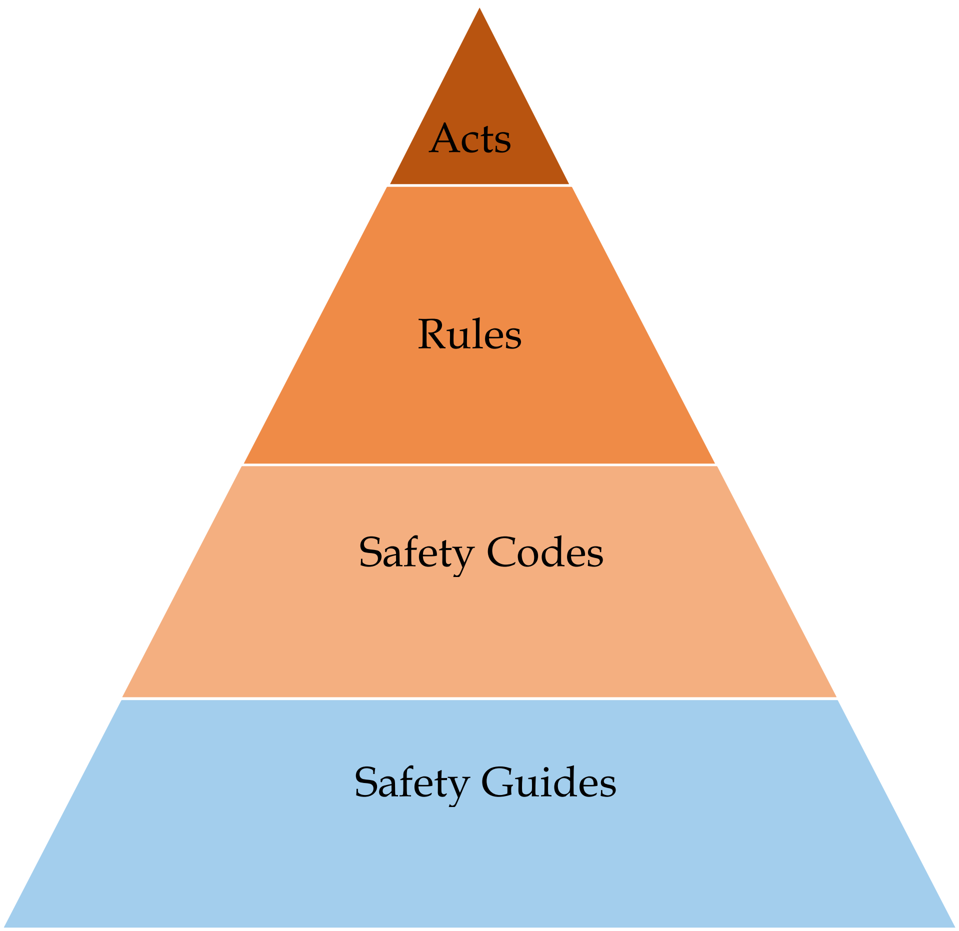
SEB: State Electricity Board

DoE: Directorate of Explosive

SBI: State Boiler Inspectorate

MHA: Ministry of Home Affairs

Annex 7-2: Regulatory documents pursuant to primary legislation pertaining to nuclear energy



Environment (Protection) Act 1986, Disaster Management Act 2005, The Water (Prevention & Control of Pollution) Act, 1974, The Air (Prevention & Control of Pollution) Act, 1981, The Water (Prevention & Control of Pollution) Cess Act, 1977, Indian Electricity Act, 2003, Indian Boilers Act, 1923; Indian Explosives Act 1884

- Atomic Energy Act, 1962
- Factories Act, 1948

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

- Regulation of nuclear and radiation facilities [AERB/SC/G]
- Safety in NPP Operation [AERB/SC/O (Rev.1)]
- QA for Safety in NPPs [AERB/SC/QA (Rev.1)]
- Site Evaluation of Nuclear Facilities [AERB/SC/S (Rev.1)]
- Design for Safety in PHWR Based NPP [AERB/SC/D (Rev.1)]
- Design for Safety in LWR Based NPPs [AERB/NPP-LWR/SC/D (Rev.1)]
- Radiation Protection for Nuclear Fuel Cycle Facilities [AERB/NF/SC/RP]
- Management of Radioactive Waste [AERB/NRF/SC/RW]

- Safety Guidelines on Emergency Preparedness (3 documents)
- Safety Guides under Code on Regulation of nuclear and radiation facilities (9 documents)
- Safety Guides under Code on Site Evaluation of Nuclear Facilities (11 documents)
- Safety Guides under Code on Design for Safety in NPPs (20 documents)
- Safety Guides under Code on Safety in NPP Operation (15 documents)
- Safety Guides under Code on Management of Radioactive Waste (4 documents)
- Safety Guides under Code on QA for Safety in NPPs (9 documents)

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ARTICLE 8: REGULATORY BODY

1. **Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 7, and provided with adequate authority, competence and financial and human resources to fulfill its assigned responsibilities.**
2. **Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organization concerned with the promotion or utilization of nuclear energy.**

8.0 GENERAL

The Government of India, exercising the powers conferred by Section 27 of the Atomic Energy Act 1962 established the Atomic Energy Regulatory Board (AERB) in 1983, to carry out regulatory and safety functions with regard to nuclear power generation and use of ionising radiations in the country. The authority of AERB is derived from the presidential notification (gazette notification) for establishment of AERB and rules promulgated under the Atomic Energy Act, 1962. The mission of AERB is to ensure the use of ionising radiation and nuclear energy in India does not cause undue risk to the health of people and the environment.

AERB is entrusted with the responsibility for regulating activities related to nuclear power generation, nuclear fuel cycle facilities, research and industrial and medical uses of radiation. AERB also regulates industrial safety as per the provision of Factories Act 1948 and the Atomic Energy (Factories) Rules 1996, for the plants and facilities managed by the constituents of DAE.

8.1 ESTABLISHMENT OF AERB

8.1.1 Mandate and Duties of AERB

The basic regulatory framework for safety for all activities related to atomic energy program and the use of ionising radiation in India is derived from Sections 16, 17 and 23 of the Atomic Energy Act, 1962. These provisions have been described in detail in Chapter on Article 7. AERB carries out regulatory and safety functions as per these sections of the Act. The mandate for AERB brought out in the presidential (gazette) notification issued by the Central Government in the year 1983 inter-alia includes:

i. Powers to lay down safety standard and frame rules and regulations in regard to the regulatory and safety requirements envisaged under the Atomic Energy Act, 1962.

ii. Powers of the Competent Authority to enforce rules and regulations framed under the Atomic Energy Act, 1962 for radiation safety in the country.

iii. 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.

The functions & responsibilities of AERB are summarized below:

i. Develop safety policies in nuclear, radiological and industrial safety areas.

ii. Develop Safety Codes, Guides and Standards for siting, design, construction, commissioning, operation and decommissioning of different types of nuclear and radiation facilities.

iii. Grant consents for siting, construction commissioning, operation and decommissioning, after an appropriate safety review and assessment, for establishment of nuclear and radiation facilities.

iv. Ensure compliance of the regulatory requirements prescribed by AERB during all stages of consenting through a system of review and assessment, regulatory inspection and enforcement.

v. Prescribe the acceptance limits of radiation exposure to occupational workers and members of the public and approve acceptable limits of environmental releases of radioactive substances.

vi. Review the emergency preparedness plans for nuclear and radiation facilities and during transport of radioactive sources, irradiated fuel and fissile material.

vii. Review the training program, qualifications and licensing policies for personnel of nuclear and radiation facilities and prescribe the syllabi for training of personnel in safety aspects at all levels. Assessment of competence of key personnel for operation of NPP.

viii. Take such steps as necessary to keep the public informed on major issues of radiological safety significance.

ix. Promote research and development efforts in the areas of safety.

x. Maintain liaison with statutory bodies in the country as well as abroad regarding safety matters.

xi. Review of "Nuclear Security affecting Safety" at Nuclear installations

xii. Notify Nuclear incident under Civil Liability for Nuclear Damage Act, 2010

Deriving powers and functions specified in the gazette notification, AERB Safety Code, AERB/SC/G: 2000 on "Regulation of Nuclear and Radiation Facilities" establishes the regulatory practices in the country.

8.1.2 Structure of AERB

8.1.2.1 The Board

The governing Board of AERB consists of a Chairman, five members and a Secretary. Chairman, AERB is the Chairman of the Board. Chairman, Safety Review Committee for Operating Plants (SARCOP) is an ex-officio member of the Board. Secretary of the Board is an employee of AERB. The other members of the Board are serving or retired eminent persons from the government, academic institutes, medical institutes, national laboratories etc.

The Board formulates the regulatory policies and decides on all important matters related to Consent, renewal of consents, enforcement actions, major incidents, etc. Chairman AERB, functions as the executive head of the AERB Secretariat. The Board reports to Atomic Energy Commission (AEC). Atomic Energy Commission is the apex body of the Central Government for atomic energy that provides direction on policies related to atomic energy. The members of AEC among others include eminent scientists, technocrats, secretaries of different ministries and senior most officials from the office of the Prime Minister. The Chairman AEC reports to the Prime Minister.

AERB sends periodic reports to AEC on safety status including observance of safety regulations, standards and implementation of the recommendations in all DAE units. In addition, the safety status for non- DAE units is covered in these periodic reports.

8.1.2.2 Committees of AERB

AERB is supported by several committees in its regulatory functions. Among them, Safety Review Committee for Operating Plants (SARCOP) and Safety Review Committee for Application of Radiation (SARCAR) are the two apex level committees for safety review and monitoring in nuclear facilities and radiation facilities respectively. SARCOP also enforces safety regulations in NPPs & other nuclear facilities under the jurisdiction of AERB.

AERB has constituted advisory committees for various regulatory activities and development of regulatory documents.

The Advisory Committee for Nuclear Safety (ACNS) advises AERB on generic safety issues affecting the safety of nuclear installations. It is also mandated to conduct the final review of draft safety documents like safety codes, guides and manuals pertaining to siting, design, construction, operation, quality assurance and decommissioning of Nuclear Facilities.

The Advisory Committee on Occupational Health (ACOH) advises AERB on the matters of occupational health in the DAE industrial units. The Committee also recommends requirements in each unit with respect to infrastructure for the occupational health activities including medical officers as well as appropriate facilities.

The Advisory Committee for Industrial and Fire Safety (ACIFS) advises AERB on generic industrial and fire safety issues and recommends measures on industrial safety aspects for prevention of accidents at all DAE installations including projects under construction.

The Advisory Committee on Radiological Safety (ACRS) advises on generic safety issues concerning radiological safety in application of radiation sources in medicine, industry, education and research.

The Advisory Committee for Review of Safety Research (AC-RSR) advises on generic safety research topics/ issues and joint research projects with other institutions in the areas of interest to regulatory body.

The Advisory Committee for Security (ACS) advises on generic security issues concerning nuclear safety aspects for nuclear power plants.

There are a few Advisory Committees constituted for advising AERB with respect to safety review and consenting of new projects.

The technical support to these Committees is provided by the experts from AERB, BARC, IGCAR, national laboratories, industrial and academic institutions in the country. The Advisory Committees are supported by various other committees. The administrative and regulatory mechanisms, which are in place, ensure multi-tier review.

8.1.2.3 Organisation of AERB

AERB has its office located in Mumbai to perform its regulatory functions. AERB has three regional offices, The Southern Regional Regulatory Centre (SRRC), the Eastern Regional Regulatory Centre (ERRC) and the Northern Regional Regulatory Centre (NRRC) to carry out regulatory inspections of radiation facilities, covering the respective region of the country. AERB has a Safety Research Institute (SRI) at Kalpakkam, which carries out research in various safety-related topics and organizes seminars, workshops and discussion meetings periodically.

AERB comprises of seven technical divisions and a safety research institute located at Kalpakkam, Tamil Nadu. These are: Operating Plants Safety Division (OPSD), Nuclear Projects Safety Division (NPSD), Nuclear Safety Analysis Division (NSAD), Radiological Safety Division (RSD), Siting & Structural Engineering Division (SSED), Resources and Documentation Division

(R&DD) and Industrial Plants Safety Division (IPSD). The organisation of AERB is given in Annex 8-1. The functions of the technical divisions of the secretariat are briefly summarised below:

Operating Plants Safety Division

- Enforcement of Atomic Energy (Radiation Protection) Rules, 2004 in operating NPPs
- Issuance of authorisation for Radwaste Disposal under Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 and their enforcement in operating NPPs and other nuclear facilities
- Safety Review of Nuclear Power Plants and Research Reactors
- Issuance of Technical Specifications for operation of Plants and Facilities
- Licensing of Operating and Management Personnel
- Regulatory Inspection of operating NPPs
- Review of Emergency Preparedness at NPPs
- Renewal of License for operation of NPPs
- Review of Nuclear security aspects affecting safety

Nuclear Projects Safety Division

- Safety Review of Nuclear Projects.
- Regulatory Inspection & Enforcement in projects under construction.
- Issue of authorizations at various stages of the projects as per established procedures and protocols.
- Review of Nuclear security aspects affecting safety in projects.

Siting and Structural Engineering Division

- Review of applications for Siting consent
- Siting & Structural Engineering issues related to Operating Plants and New Projects.
- Inspection and Enforcement of Civil& Structural Engineering safety
- Earth Science and Earthquake Engineering Aspects

Nuclear Safety Analysis Division

- Probabilistic Safety Assessment.
- Deterministic Safety Analysis.
- Safety Review of Indian Nuclear Power Plants.
- Nuclear Regulatory Research.
- Independent check for resolving issues related with nuclear plant safety requiring analysis to be carried out.
- Review & regulatory inspections of reactor physics aspects

Radiological Safety Division

- Enforcement of Atomic Energy (Radiation Protection) Rules, 2004 in radiation installations other than Nuclear Fuel Cycle Facilities
- Safety Review of Accelerators and Irradiators
- Transportation of Radioactive Material
- Enforcement of Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 in radiation installation other than Nuclear Fuel Cycle Facilities

Industrial Plants Safety Division

- Industrial and fire Safety Review
- Regulatory Inspection related to Industrial Safety
- Licensing of Personnel
- Occupational Health of Workers Inspection and Enforcement of radiological safety in fuel cycle facilities other than NPPs

Resources and Documentation Division

- Regulatory document development
- Information and Technology Services
- Human Resource management
- Training
- Public outreach

Safety Research Institute

- Nuclear & Reactor Safety Studies
- Radiation Safety Studies
- Nuclear Plant Thermal Hydraulics
- Fire Safety Studies
- Environmental Safety Studies

The Heads/Directors of the above divisions are members of the AERB Executive Committee which meets periodically and takes decisions on important functional matters. The management of external affairs of AERB is carried out by External Relations Officer.

8.1.2.4 Technical Support

BARC is the main technical support provider to AERB. It has a MoU with AERB for technical support in the field of regulation of nuclear and radiation facilities in India. BARC also provides technical support in the areas of development of safety documents, radiological and environmental safety, review and assessment of safety cases and inspection and verification functions. Some of the other important areas where BARC provides extensive technical support to AERB are Reactor Physics, Reactor Chemistry, Post-irradiation Examination, Remote Handling and Robotics, Control and Instrumentation, Shielding, Thermal Hydraulics, Probabilistic Safety Assessments, Seismic Evaluation, Quality Assurance and In-service Inspection. BARC is currently involved in the following R&D activities for improving the analytical capabilities in the areas related to nuclear safety:

- Experimental program for validation of leak flow models for cracks specific to PHWR feeder piping
- Establishment of analytical models for channel disassembly process and debris bed heat up through experiments for development of severe accident code PRABHAVINI
- Participation in computer code validation exercise for IAEA ICSP on HWR moderator sub cooling requirements demonstration under accident condition
- Aerosol and fission product retention model validation experiments for PHWR and AHWR
- Participation in benchmark analysis for OECD/NEA HYMERES project to enhance modelling techniques of CFD codes used to predict hydrogen distribution in containment
- Development and application of meteorological and atmospheric dispersion model and radiological impact assessment of gaseous radioactive discharge into atmosphere

AERB utilizes the expertise available with Indira Gandhi Centre for Atomic Research (IGCAR). Experts from Council for Scientific & Industrial Research (CSIR) and various Indian Institutes of Technology (IITs) also provide technical support to AERB in its review and assessment functions. AERB appoints consultants having long experience in the national nuclear programme in various capacities for supporting it in the regulatory activities. AERB may also invite experts from other organisations having specific expertise. Another important resource for AERB's safety review and safety documents development work is the large pool of retired senior experts.

The technical support from BARC, IGCAR, national laboratories, and industrial and academic institutions in the country to AERB also comes in the form of providing experts as members for its advisory committees and safety committees.

8.1.2.5 Human Resources

The staff of AERB mainly consists of technical & scientific experts in different aspects of nuclear and radiation technology for meeting the requirement of consenting, safety review, research, inspections and analytical works. Besides AERB's own staff, required expertise is drawn from Technical support organisation, premier research centers, academic institutions and retired experts. AERB has a staff strength of 326 as on March 2016. AERB is currently augmenting its staff strength to reach about 450 in the near term. Fresh technical & scientific staff is inducted from various training schools and nuclear training centres as well as from Indian Institutes of Technology. Direct recruitment of experienced professionals is also done through open advertisements. The recruitment and training process is as follows:

i. Engineering graduates are absorbed after basic training in nuclear training centres at NPP sites. They undergo 2 years field training at NPPs to gain the system knowledge including simulator training before obtaining the NPP operations license. Some are also deputed during construction/commissioning activities of NPP to obtain the field experience.

ii. Engineering/Science graduates are also absorbed after their basic training from BARC training Schools. They are given on-job training at operating NPPs. They generally pursue specialisation in the areas of reactor physics, nuclear and radiological safety, transport safety and waste management and also complete post-graduation in their field.

iii. AERB sponsors a few students annually to complete the post-graduation from Indian Institutes of Technology. They are further trained in nuclear technology and given on-job training at NPPs after which they are assigned analytical and research activities to support the regulatory decision making process.

iv. AERB through its Safety Research Institute sponsors its employees for Post-Doctoral courses to develop expertise in the areas of regulatory interest. AERB also encourages persons to take up higher studies in the field of nuclear engineering.

Such an extensive training to fresh recruits before involving them in the regulatory job plays an important role towards their competence development.

In addition, AERB organizes in-house orientation training program for newly inducted staff. This program covers the subject such as legislative and regulatory framework (Acts, Rules, Codes, Guides and Manuals), functioning of AERB, regulatory processes followed and basic aspects of nuclear, radiation and industrial safety in nuclear and radiation facilities. This training program is of approximately two months duration.

In-house refresher courses are conducted on various topics of regulatory and safety aspects. AERB colloquia are organised frequently on topics of current interests and on new developments in various fields. The staff is provided opportunity to participate in conferences, seminars, and workshops in India as well as abroad to keep them abreast of the new developments in the areas of relevance. In addition, seminars / theme meetings, technical talks are arranged by the respective divisions of AERB to encourage more and more interaction with the stakeholders.

8.1.2.6 Financial Resources

AERB has full powers to operate its budget, which it prepares and submits to the Central Government for approval. The Central Government allocates the budget in the separate account heads of AERB. The budget of AERB in the year 2016-2017 is about ₹1060 million. This budget does not include the cost of Technical Support provided by different organisations.

8.1.2.7 Safety Research

A large part of safety research important to regulatory activities is carried out by BARC, the technical support organisation. AERB also has its own Safety Research Institute (SRI) at Kalpakkam near the city of Chennai in order to achieve independent research and development capabilities and to complement the ongoing research and development work done in other R&D centres. The areas of research at SRI ranges from Light Water Reactor Physics, Fire Modelling Studies, Radiation Shielding & Transport and Criticality Computations, Assessment of Beam Characteristics of Medical linear particle accelerators, Reliability and Probabilistic Safety Assessment, Structural and Seismic Studies, Remote Sensing and Geographic Information System Applications, Safety Assessment of near surface disposal facilities. The institute helps building up competent human resources of high merit for regulatory purposes. It also organizes workshops and seminars on specific safety topics of current importance.

AERB also promotes and funds radiation safety research and industrial safety research as part of its programme and provides financial assistance to universities, research institutions and professional associations for holding symposia and conferences on the subjects of interest to AERB. AERB Committee for Safety Research Programmes (CSRP) frames guidelines for the same and also evaluates and monitors the research projects.

8.1.2.8 Quality Management in AERB

The AERB established a Quality Management System (QMS) compliant with ISO 9001:2008, which is certified by accreditation body. The AERB's main processes (consenting, regulatory inspection and development of regulatory documents) are defined in QMS since 2006. In order to integrate the regulatory /management processes not covered under QMS, AERB is in the process of establishing Integrated Management System in line with IAEA GS-R-3 requirements. In the year 2015, AERB started to migrate the existing QMS system into an Integrated Management System (IMS) and developed implementation plan.

8.2 STATUS OF THE AERB

8.2.1 Government Structure and the Regulatory Body

The Constitution of India places atomic energy and mineral resources necessary for its production under the Union List (List I- Seventh Schedule), pursuant to which the laws pertaining to atomic energy are enacted by the Parliament and enforced by the Central Government. The Atomic Energy Act, 1948 was the first legislation pertaining to the atomic energy in the country. In the same year, the Government of India constituted a high powered Atomic Energy Commission to implement the Government's policy with regard to the atomic energy. Subsequently in the year 1954, Government of India created Department of Atomic Energy (DAE). With the creation of DAE, AEC was reconstituted in accordance with the Government resolution dated March 1, 1958, to advise the Central Government on matters pertaining to the atomic energy. Later, Central Government constituted Atomic Energy Regulatory Board (AERB) in 1983 and delegated to it the power to exercise certain regulatory and safety functions envisaged under the Atomic Energy Act 1962 and rules thereof. AERB updates the AEC through annual report on all safety related matters pertaining to nuclear and radiation related activities in India.

8.2.2 Obligations of the Regulatory Body

The Presidential (Gazette) notification, constituting AERB, issued by the Central Government in the year 1983 empowers AERB for issue of consents, regulatory inspection and enforcement of safety provisions for nuclear and radiation facilities in India. According to the same notification, the functions of AERB also include:

i. Development of necessary rules and regulations to implement the provisions of the Act in the area of nuclear and radiation safety.

ii. Prescribing acceptable limits of radiation exposures and environmental releases of radioactive substances.

iii. Carrying out safety review on the basis of established regulatory requirements towards considering the grant of regulatory consent;

iv. Conducting regulatory inspections to ensure adherence with the laid down safety requirements and taking enforcement measures, as necessary and

v. To take necessary steps to keep the public informed on major issues of radiological safety significance.

8.2.3 Effective Separation between Regulation and Promotion Activity

The Atomic Energy Commission (AEC) is a high level body dealing with policy matters concerning nuclear energy in the country. Under the framework of the Atomic Energy Act, 1962 companies and organisations under the Department of Atomic Energy (DAE) carries out the activities related to development of nuclear power, applications of radiation technologies in the fields of agriculture, medicine, industry and basic research etc. There are a number of Public Sector Undertakings under DAE for carrying out activities pertaining to nuclear power production like Uranium Corporation of India Ltd. (UCIL) for mining and milling of uranium and Nuclear Fuel Complex (NFC) for fabrication of fuel, NPCIL and BHAVINI for design, construction and operation of NPPs etc. All these public sector undertakings have been developed as ‘Government Companies’ and the Atomic Energy (Amendment) Act, 2015redefines the nature of such companies.

AERB, the national safety regulator, is a separate body constituted by the Central Government specifically for exercising certain regulatory and safety functions envisaged under the Atomic Energy Act, 1962 and various rules thereof. Funding for AERB activities is provided by Government of India. AERB enjoys full functional independence from DAE or any other agency in its functioning and its reporting to AEC is limited to presenting its Annual Report and Budget Proposals only once in a year. The Chairman AERB is the ‘competent authority’ under various rules promulgated under the Atomic Energy Act, 1962 on radiological safety. The effectiveness of this functional separation accorded to AERB while carrying out safety regulation in India has also been ascertained by the IAEA-IRRS Mission to India in its report.

In 2011, Government had introduced the ‘Nuclear Safety Regulatory Authority (NSRA) Bill 2011’ in the Parliament with the objective of separation of primary legislation concerning regulation of nuclear and radiation facilities from other aspects. The Bill was reviewed by various committees of the Parliament. With the expiry of the term of the 15thLok Sabha (The Lower House), the government is currently again processing the same.

8.3 CO-OPERATION WITH INTERNATIONAL BODIES

AERB has been actively involved with various international bodies for exchange of information and in co-operation in the field of regulation of nuclear activities for peaceful purposes. AERB experts have been actively participating in various activities of IAEA and have been contributing at various other international fora. Some of these co-operation activities are brought out as follows:

i. International Atomic Energy Agency (IAEA)

AERB has been actively participating in the activities of IAEA. The staff of AERB participates in various Technical and consultants meetings organised by IAEA on a range of topics for fuel cycle activities, radiation facilities, transportation of radioactive materials and illicit trafficking of radioactive materials. AERB has been participating in IAEA Coordinated Research Programme (IAEA-CRP).

AERB is the national coordinator for IAEA –International Nuclear and Radiological Event Scale (INES) and IAEA - Incident Reporting System (IRS). AERB participates in all activities related to their functioning.

These interactions help AERB in keeping abreast with the developments in the related fields, safety issues and the evolving safety standards. The experience helps AERB in developing national standards and guidelines.

Post Fukushima accident, senior officials of AERB participated in the IAEA ministerial conference in 2011 & 2012 and IAEA Fact Finding Mission to ascertain factual information and to identify initial lessons learned from the accident. AERB has participated in the various meetings organised by IAEA and presented the review findings, actions taken/proposed. AERB has been participating in some specific IAEA activities related to external events. AERB has recently joined the activities of International Seismic Safety Centre (ISSC) of IAEA and is participating in four work areas viz., Seismic Safety Evaluation, Tsunami Hazards, Engineering Aspects of protection against sabotage and site evaluation and external events safety assessment.

AERB in association with Indian Nuclear Society (INS) and other units of Department of Atomic Energy (DAE) organized an international workshop on the theme 'NPPs: Safety and Sustainability' during December, 2015. The workshop combined two international workshops, 'CANDU Safety association for Sustainability' (CANSAS-2015) and 'New Horizons in Nuclear reactor Thermal-hydraulics and Safety' (IW-NHNRTHS). Senior experts from the regulatory bodies, research establishments, operating organisations as well as designers and suppliers from around the world participated in the workshops of CANSAS and IW-NHNRTHS. The workshop, among other aspects, focused on areas related to R&D activities regarding PHWR safety, design innovations in PHWR fuel, severe accident management guidelines, and challenges in safety regulation.

Recently officials from AERB participated as members in the IAEA's Integrated Regulatory Review Service (IRRS) Missions to The Netherlands, Armenia and Indonesia. AERB plays an active role in strengthening the global safety regime and towards this contributes in various meetings, peer review missions and development of safety standards of IAEA. AERB also utilizes experience gained through these safety-cooperation activities towards further augmenting safety regulatory system within India.

ii. Nuclear Energy Agency

India has been involved in the activities of committees of NEA and their various working groups such as Committee on Safety of Nuclear Installations (CSNI) and Committee on Nuclear Regulatory Activities (CNRA). India has participated in the following working groups:

- Working Group on Operation Experience (WGOE),
- Working Group on Inspection Practices (WGIP),
- Working Group on The Regulation of New Reactors (WGRNR),
- Working Group on Public Communication of Nuclear Regulatory Organisations (WGPC)
- Working Group on Risk Assessment (WGRisk),
- Working Group on Analysis and Management of Accident (WGAMA)
- Working Group on Integrity and Ageing of Components and Structures (IAGE)
- Working Group on Fuel Safety (WGFS)
- Senior-Level Task Group on the impacts from Fukushima Daiichi accident (STG Fukushima).
- Senior-Level Task Group on Defence-in-Depth (STG DiD).

iii. Multinational Design Evaluation Programme (MDEP)

AERB is member in Multinational Design Evaluation Programme (MDEP) since year 2012. AERB is actively participating in the Policy Group (PG) and Steering Technical Committee (STC) apart from participation in one of the issue specific working groups 'Digital Instrumentation and Control Working Group (DICWG)', Code and Standards Working Group (CSWG) and Vendor Inspection Co-operation Working Group (VICWG)

India is also participating in the activities of VVER working group and its subgroup working in the areas such as Reactor Pressure Vessel, severe accident, and Fukushima Lesson Learnt.

iv. CANDU Senior Regulators Forum

AERB is a member of the forum for the CANDU Senior Regulators for exchange of information on issues specifically related to safety of PHWRs. The Annual Meeting "CANDU Senior Regulators' Meeting" of Senior Regulators from member countries of CANDU Senior Regulator Group for the year 2014 was hosted by AERB in India in November, 2014. AERB also participated in annual meeting held in November 2015 in Canada.

In the meeting, the Senior Regulators deliberated on the aspects related to (i) I&C aspects of CANDU reactors, (ii) source term assessment methodology, (iii) radiological impact assessment, (iv) possible measures for avoidance of long term offsite contamination. These areas are of common interest to CANDU operating countries in the current scenario.

AERB is one of the key contributors in CANDU PSA Working Group established by IAEA as suggested by CANDU senior regulators forum. The objectives of the CANDU PSA Working Group are to support regulatory authorities, utilities and designers in their area of PSA by harmonizing regulatory approaches and utilities practices on the use of PSA and to make recommendations to CANDU Senior Regulators Forum.

v. VVER Regulators Forum

VVER Regulators Forum is for exchange of information and experience on issues specifically related to safety of Russian VVERs. AERB is a member of this forum and regularly contributes to the activities of the Forum. AERB participates in the PSA Working Group, Reactor Physics Code Verification with commissioning data and strengthening commissioning programme of new VVER NPPs based on commissioning experience/operating experience, Working Groups of VVER Regulator's Forum. AERB's participation in this forum helps in understanding events and generic safety issues in VVER reactors, based on which corrective steps as may be necessary are initiated in NPPs at Kudankulam, where in one unit is under operation while the second is under advanced stage of commissioning for power operation in India. Officials from AERB recently participated in the 23rd Annual Meeting of the Forum held in July 2016 in Russia.

vi. United States Nuclear Regulatory Commission (USNRC)

Cooperation in nuclear safety between AERB and USNRC was resumed in February 2003. Since then fourteen meetings have been held between AERB and USNRC both in India and USA. The objective of these meetings continues to be furthering the dialogue regarding Nuclear Safety between US and Indian Governments.

As a part of nuclear safety cooperation programme between AERB and USNRC, a bilateral meeting was held in October, 2015 at AERB, Mumbai. The meeting was attended by NRC delegates and officials from AERB, BARC and NPCIL. In the associated workshop, safety experts from both the countries shared their experiences on regulatory practices and discussed various safety aspects regarding issues related to Digital I&C Systems, Containment Pressure Assessment and Equipment Qualification Program under Design Extension Conditions, AMG requirements etc.

vii. ASN and IRSN, France

AERB and Nuclear Safety Authority (ASN), France discussed safety issues of mutual interest including emergency preparedness and management of post accidental situations and safety reviews carried out after Fukushima accident. A two day workshop was also conducted with safety experts from both the countries presenting the latest practices adopted by them. Both the countries have conducted such meetings and workshops in the past also under the Nuclear Safety Co-operation Arrangement between the two organizations that was signed in July 1999 and further renewed in 2005,2010 and recently in 2016.

Another agreement on technical cooperation between AERB and Institute for Radiation Protection and Nuclear Safety (IRSN), France was also signed in the year 2010 and further renewed in 2015 for collaboration in the area of nuclear reactor safety covering areas such as exchange of staff, exchange of materials or software, joint studies and joint projects etc. A separate agreement for the use of IRSN software ASTEC was also signed in 2012.

viii. Radiation Safety Authority, Russia

AERB and the Federal Nuclear and Radiation Safety Authority of Russia ROSTECHNADZOR entered into an agreement for cooperation in the field of safety regulation of nuclear energy for peaceful purposes. This agreement came into force on February 15, 2003 and is valid till Kudankulam NPP begins regular operation. Four Workshops have been held between AERB and ROSTECHNADZOR for information exchange on nuclear safety.

ix. CNCAN, Romania

A Memorandum of Understanding (MoU) was signed between AERB and National Commission for Nuclear Activities Control (CNCAN) of the Government of Romania on September 19, 2012. The MoU is signed for the exchange of information and co-operation in the field of regulation of nuclear activities of peaceful purposes such as application of radiation for societal benefit in industry, medicine, agriculture and research & field of regulating nuclear and radiation safety.

x. SNRIU, Ukraine

A Memorandum of Understanding (MoU) was signed between AERB and State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) on December 10, 2012. The MoU is signed for the exchange of information and co-operation in the field of regulation of nuclear activities of peaceful purposes such as regulatory process, nuclear safety, radiation protection, emergency planning, environmental impact evaluation of nuclear facilities, quality assurance and sharing of operating experience including information concerning research and development programs.

xi. CNSC, Canada

AERB signed an arrangement with regard to cooperation and exchange of nuclear regulatory information with the Canadian Nuclear Safety Commission (CNSC) in September 2015. The agreement inter-alia provides for regulatory cooperation pertaining to exchange of information and the officials of the regulatory authorities, training of personnel in the field of nuclear and safety regulation.

xii. STUK, Finland

In 2014, AERB and the Radiation and Nuclear Safety Authority of Finland (STUK) signed an arrangement for cooperation in the field of nuclear and radiation safety regulation. The agreement amongst other things provides for the exchange of information and personnel, use of information and rights and obligations of both the regulatory authorities.

8.4 INTERNATIONAL PEER REVIEW OF AERB: IAEA-INTEGRATED REGULATORY REVIEW SERVICE (IRRS)The IAEA - IRRS Mission visited India during March 16-27, 2015. The IRRS team comprised 16 experts from the nuclear regulatory authorities of Bulgaria, Canada, Czech Republic, Finland, Hungary, Israel, Netherland, United Kingdom, United States of America, and the IAEA itself. The team members held discussions with the counterparts on various aspects of regulatory framework established for safety of NPPs and verified evidences corroborating the stated position in the Self-Assessment Report submitted to IAEA as a part of Advance Reference Material. Few members accompanied the Regulatory Inspection team to an operating nuclear power plants as well as a nuclear power project for observing the inspection process of AERB.

The detailed outcome of the mission was submitted to India by IAEA in form of Report on IRRS Mission to India, which was made available to the public through AERB's web-site (www.aerb.gov.in). The report among other things, identified few good practices of India's safety regulatory framework and also suggested a few recommendations and suggestions to further improve existing legal set-up and a few regulatory processes. The areas, wherein IRRS team identified a few good practices include the following

- India's unique educational and training system to support competence building,
- regulatory processes for utilization of operational and regulatory experience feedback,
- R&D infrastructure established to support regulatory activities
- The scope and depth of AERB's recruitment programme and
- Aspects related to management processes for tracking outcome of emergency exercises

IRRS team also made certain recommendations to further strengthen the existing legal and regulatory aspects regarding;

- independence of AERB(securing the independence of regulatory body in the law)

- while the National policy and strategy for safety has been established throughout the legal and regulatory framework, it needs to be promulgated as a formal policy/ strategy by Government (adoption and publication of national policy and strategy for safety; promulgation of a national radioactive waste management strategy)
- formalization of a few good practices of AERB (establishing guidance with respect assisting staff members in implementation of graded approach; reviewing the existing arrangements to insure independence in AERB's regulatory functions; fully develop its processes related competence mapping; establishing a communication strategy to effectively engage various stakeholders)
- strengthening the management system(finalize the implementation of Integrated Management System; develop internal procedures to review organizational changes at NPPs; addition of specific guidance in documents on regulatory inspections with regard to unannounced inspections)
- improvements in regulatory functions (review and revise the regulatory requirement on declaration of an offsite emergency; revise applicable safety codes and guides to clarify the designation and responsibilities of various officials having a role in management of the emergency; develop and implement its own internal emergency arrangements including detailed procedures)

The IRRS team also identified 21 suggestions to further strengthen current regulatory framework.

8.5 INFORMATION TO PUBLIC

AERB provides all necessary information to its stakeholders through its periodic newsletters, annual reports, web-site, press releases/ briefings and TV interviews. The AERB annual reports contain information on safety status of nuclear facilities and findings of regulatory reviews. It also includes information on safety significant events reported by licensee and the regulatory inspectors. AERB website plays a pivotal role in keeping the public informed on issues related to radiological safety, major regulatory decisions and special technical reports etc. The AERB Bulletin, which is the popular version of the Annual Report of AERB, presents the most important activities in a more understandable and public friendly format. These bulletins are presented in a few local languages too for wider public outreach. AERB sought the views/ comments from public and other interested parties on the draft of the newly developed regulatory documents towards assessing the effectiveness of such process.

Formal sharing of information with any member of the public on request is a statutory responsibility of AERB under the "Right to Information" Act, 2005. Commensurate with the established formal processes in India, AERB also responds to the queries put forth by the Members of the Parliament along with the substantiating information, as necessary. These responses are made public on the websites of the Parliament. AERB's mandate includes such steps as necessary to keep the public informed on major issues of radiological safety significance. AERB explains the decision-making process to its stake holders; involves the relevant stake holders and experts in development of regulatory documents. AERB regularly conducts regulatory awareness programme which includes seminars, discussion meetings, conferences and feedback meetings.

Subsequent to the incidents of leak from pressure tubes at KAPS-1&2, AERB promptly issued a press release on the safety status of the plant and functioning of respective safety systems. Thereafter, AERB kept the public/media engaged by issuing updates on the incident.

AERB regularly participates in the meetings of the NEA Working Group on Public Communication of Nuclear Regulatory Organisations (WGPC).The purpose of the WGPC is to facilitate the exchange of information, news, documents, experiences and practices among nuclear regulatory organisation communicators. Recently, AERB participated in the third international stakeholders' workshop held by WGPC in Tokyo, Japan.

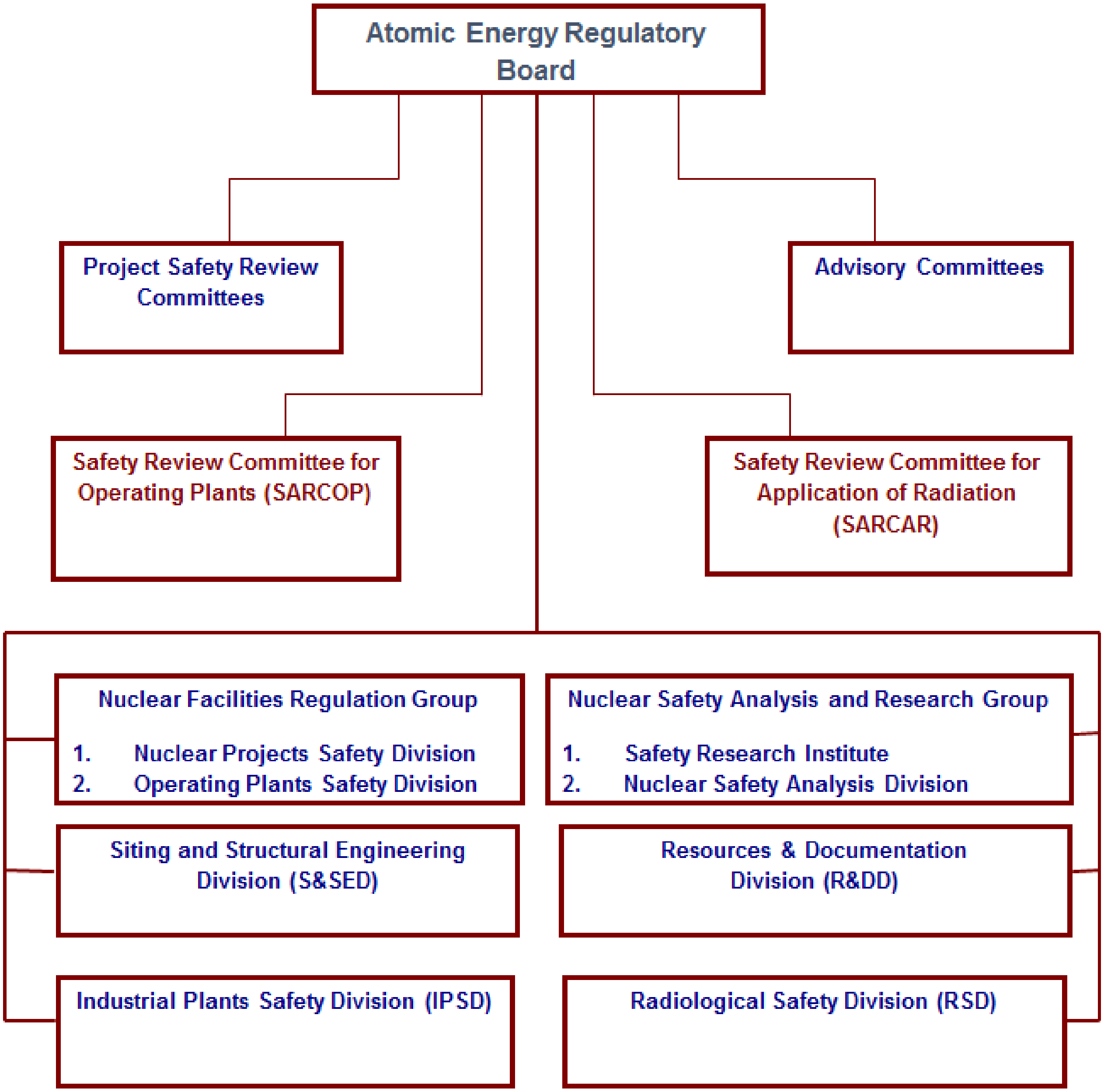
After the conclusion of the IRRS Mission, AERB held a press-briefing for disseminating the information on the international peer review of the safety regulatory activities in India. Further, India also made public the report of IRRS Mission on AERB's website. The outcome of statutory audits of AERB's regulatory activities has also been made public together with their assessment by high level parliamentary committees.

In order to formalise its methodology related to sharing of information and engaging with the media and the general public, a formal communication strategy is being issued. .

8.5 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

As atomic energy programme in India is expanding, the regulatory body has made significant efforts to keep pace with the developments. Since its constitution in 1983, AERB has built up its technical and managerial capabilities to meet these requirements. The position of AERB in the government set up ensures administrative and financial independence in its functioning. The Central Government provides the financial resources to AERB according to its proposed budget. Technical support is drawn from various national laboratories as well as from other national academic and research institutions. The statutory and legal provisions of the Atomic Energy Act and various rules framed thereunder and the powers conferred by the gazette notification provide AERB with the necessary authority for independent and effective functioning. Hence, India complies with the obligations of Article 8 of the Convention.

Annex 8-1: Organisation Structure of AERB



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ARTICLE-9: RESPONSIBILITY OF THE LICENCE HOLDER

Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

9.0 GENERAL

Under the Atomic Energy Act 1962, a license is required for acquisition, production, use, export or import of any plant designed or adopted or manufactured for the production and development of atomic energy or research. The Act requires that only Central Government or any authority or corporation established by Central Government or a Government Company can produce, develop, use and dispose atomic energy and carry out research into matters connected therewith. The Atomic Energy (Amendment) Act, 2015 makes consequential amendments and re-defines the term ‘Government Company’. Any licence granted to a Government company shall stand cancelled in case the licensee ceases to be a Government company. .

Nuclear Power Corporation of India Limited (NPCIL) is a Public Limited Government company, under the Companies Act 1956, fully owned by the Government of India. It undertakes design, construction, commissioning, operation & maintenance, refurbishment & upgrades and decommissioning of NPPs in the country. The mission of NPCIL is to develop nuclear power technology and produce nuclear power as a safe, environmentally benign and an economically viable source of electrical energy to meet the increasing electricity needs of the country. The Government of India has also established another company Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI) in 2003, fully owned by it to pursue construction, commissioning, operation and maintenance of Fast Breeder Reactors for the generation of electricity.

Licensee is solely responsible for ensuring the safety in design, construction, operation, maintenance and decommissioning of NPPs. It is the responsibility of the licensee and its constituent units to perform their activities as per the regulatory requirements and demonstrate to the regulatory body that all the activities of the NPP meet the established safety norms.

The report describes, inter alia the systems and organizational set-ups in NPCIL. Broadly all requirements/obligations as applicable to NPCIL with regard to responsibility of license holder are also applicable to BHAVINI. Hence, all aspects discussed in the report relating to NPCIL are also to be read as applying to BHAVINI too. However, as NPCIL is currently involved with light water and heavy water reactors and BHAVINI with fast breeder reactor, specific requirement related to the respective reactor technologies would be different. Presently, BHAVINI is involved in construction of Prototype Fast Breeder Reactor at Kalpakkam and does not operate any nuclear power plant.

9.1 NATIONAL LAWS AND REGULATIONS

Atomic Energy Act 1962 and the rules framed there-under provide the main legislative and regulatory framework pertaining to atomic energy in the country and provide for the development, control and use of atomic energy for the welfare of the people of India and for other peaceful purposes and matters connected therewith. ‘Atomic Energy (Radiation Protection) Rules, 2004’ issued under the Atomic Energy Act defines the ‘Responsibilities of Licensee’. As per the rules, the Licensee shall ensure compliance with the safety Standards and Safety codes issued by the competent authority (AERB) from time to time.

AERB Safety code on ‘Regulation of Nuclear and Radiation facilities AERB/SC/G:2000’’, brings out requirements and obligations to be met by nuclear or radiation facility to qualify for issue of regulatory consent at every stage. As per the safety code, the licensee is solely responsible for ensuring the safety in siting, design, construction, commissioning, operation and decommissioning of a Nuclear Power Plant and shall demonstrate to regulatory body that the safety is ensured at all the times. The Safety Code on Safety in Nuclear Power Plant Operation (AERB/NPP/SC/O) also specifies that the Responsible Organisation, as Consentee, shall have the primary responsibility for the safe operation of the NPP.

9.2 RESPONSIBILITIES OF LICENSEE AND MEANS TO FULFILL OBLIGATIONS

The applicant seeking consent submits all the necessary information to the AERB as laid down in the requisite regulation in support of the application for consent. The licensee is responsible to make proper arrangements with vendor(s) and/or contractor(s) to ensure availability of all the required information and also keep the regulatory body constantly informed of all relevant additional information or changes in the information submitted earlier..

The licensee has the responsibility for compliance with the stipulated requirements, regulations and conditions referred or contained in the consent or otherwise applicable. The licensee is responsible for carrying out the activities in accordance with the approved Quality Assurance program and to ensure that every step is carried out keeping safety as the overriding priority. Among others, the responsibility of the licensee is to:

i. ensure that the operation of NPP is carried out according to the relevant laws, regulations and condition of the license granted.

ii. develop, preserve, update and maintain a complete set of records related to the safety of the plant.

iii. provide the authorized representatives of AERB full access to personnel, facilities and records that are under the control of consentee.

iv. keep AERB fully and currently informed with respect to any significant events or potential for significant event or changes in the considerations, information, assumptions, or expectations based on which the consent was issued.

v. take such corrective actions or measures as required by AERB for safety.

vi. not undertake any activity beyond those authorised in the license, without the prior approval of AERB.

vii. report all accidents and events related to safety.

viii. keep AERB informed of the changes in station management positions.

ix. ensure that an adequate level of safety shall be maintained during operation through proper operational and maintenance procedures.

x. establish policies to achieve high standards of safety and promote safety culture in the organisation.

xi. make sure that the organizational structures and training & qualification of the operating personnel are adequate to achieve required level of safety.

xii. make sure that the stated procedures for surveillance, operation, maintenance and emergency planning are up to date and followed.

xiii. make sure that radiation protection of the public and the plant personnel is according to the radiation protection regulation. Radiation doses to the public & plant personnel & radioactive discharges from the NPPs are consistent with the principle of ALARA.

xiv. make sure that after a stoppage mandated by AERB, the cause of stoppage has been resolved to the satisfaction of AERB.

xv. make sure that the conditions for renewal of consent as prescribed by AERB are met.

NPCIL Corporate Management System elaborated in the document "Corporate Management System – Quality Management System Requirements" provides the necessary directives for implementation, maintenance, assessment, measurement and continual improvement of the management system for compliance with the regulatory requirements and intents in all phases of the NPPs. This document is applicable for design, procurement, manufacturing, construction, commissioning and operations and other supporting processes for the NPPs. The chapter on Article-13 on Quality Assurance describes the Safety Management System of NPCIL. The chapter on Article-14 describes the assessments and verification of safety carried out within the utility. A typical organisation put in place at an operating NPP to discharge its responsibilities is given in chapter on Article 19 (Operation). Chapter on Article-11(Financial and Human Resources) covers adequacy of resources for effective management of accident.

9.3 REGULATORY MECHANISMS TO ASSESS SAFETY PERFORMANCE OF UTILITY

The regulatory control for assurance of safety during all the stages of NPPs is exercised by AERB through a system of consenting, which authorises the specified activity and prescribes requirements and conditions. The AERB prescribes the safety requirements for all stages of NPPs through its regulatory documents, directives and licensing conditions and ensures their compliance by utilities.

License for operation of NPP is issued for a maximum period of five years. After the issuance of license for operation, AERB ensures regulatory control over the activities of licensee by way of reporting obligations, inspections and Periodic Safety Review (PSR). For NPPs under construction as well as during operation, AERB monitors safety and ensures compliance with the regulatory requirements by establishing mechanisms of review and assessment, regulatory inspection and enforcement.

The licensing process for the NPP is described in detail in Chapter on Article 14 (Assessment and Verification of Safety) of this report. A typical mechanism for regulatory control of an operating NPP is described below:

i. AERB follows a multi-tier review system of safety committees to carry out review and assessment for different stages of consent.

ii. For each operating NPP, the Unit Safety Committee (USC), the Safety Review Committee for Operating Plants (SARCOP) and the Board of AERB constitute the multi-tier review organs for regulatory control.

iii. Station Operation Review Committee (SORC) of the licensee reviews all the safety related and operational issues and proposals and forwards to the Safety Review Committee at the HQ (NPC-SRC) which reviews the submission and along with its comments, submits to Unit Safety Committee (USC) of AERB.

iv. The USC assists SARCOP in the review and assessment function to ensure comprehensive safety review on a regular basis.

v. SARCOP is an executive committee for monitoring the safety status and enforcing the regulatory norms applicable to the NPPs in operation and other associated facilities.

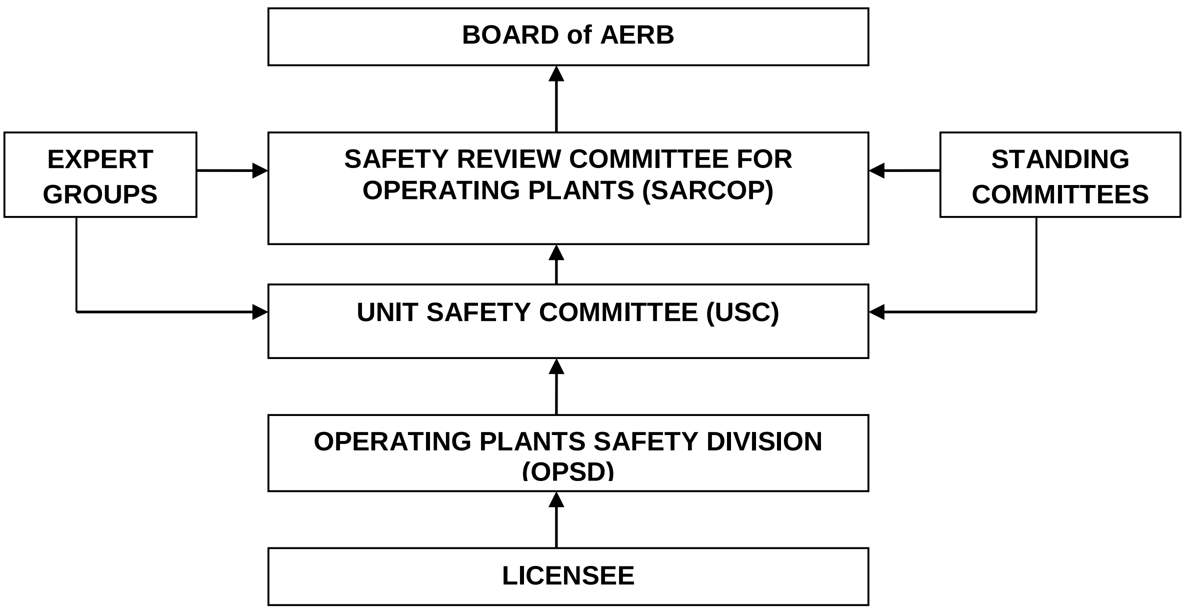
vi. SARCOP has also established various Standing Committees and Expert Groups to review and submit its observations and recommendations to USC and SARCOP on the subjects referred to them.

vii. The Operating Plants Safety Division (OPSD) is the nodal agency within AERB for coordinating the functioning of various safety committees constituted for review of operating plants and synthesising their decisions.

viii. This system of safety committees function on the principle of "management by exception" following a graded approach and are based on principles and requirements laid down by AERB.

ix. The safety issues of greater significance are considered in the higher-level safety committees for resolution. The decisions of these committees concerning major policy issues and important consents require endorsement of the governing Board of AERB.

x. The multi-tier review mechanism followed for an operating NPP is shown below.



The USC and SARCOP periodically review the safety performance of the respective units to derive assurance that the NPPs are being operated within the conditions specified in the license for operation and that the overriding priority to safety is the corner stone of the policy of operating organisation. OPSD carries out the periodic regulatory inspections, both announced and unannounced, to verify the compliance with regulatory requirements at NPPs. The areas of review, assessment, regulatory inspections and enforcements are described in chapter on Article 14 (Assessment and Verification of Safety).

9.4 OPENNESS AND TRANSPARENCY

Openness and transparency are two key attributes to achieve confidence of the stakeholders. DAE and NPCIL have been carrying out various public awareness activities in a structured manner for the dissemination of accurate and authentic information on nuclear power and other associated aspects to different target groups on sustainable basis. To achieve this, all modes of communication are being utilised to reach out to the masses. Special emphasis of awareness is placed on public living in the vicinity of operating stations and upcoming projects. Use of TV commercials, promos in digital cinema, radio jingles, publications, advertisements, advertorials, street plays , exhibitions , lectures, scientific meets for professionals and media, visit to nuclear power plants, mobile Exhibitions in villages, roping in professional PR agencies are some of them.

A state-of-the-art permanent “Hall of Nuclear Power” at New Delhi spread over 500 square metre was inaugurated and dedicated to the nation on January 16, 2016. The objective of setting up the gallery is to make people aware about various aspects of nuclear energy through various interactive and user-friendly innovative exhibits. The gallery is comprised of innovative displays, touch screen kiosks, interactive games, panels, banners, placards, cut-outs, static/dynamic models, audio/visual presentations, 2D/3D films, quiz, games etc. One of the most striking parts of the gallery is the “Digital Walk-through”, which enables visitors to feel as if they were moving inside a nuclear power plant.

Another similar gallery exists since the year 2011 at Nehru Science Centre, Mumbai wherein around one million persons visit annually. There is a plan to create many more nuclear galleries across the country in the next 5 years.

Various Articles, Reports, Press Releases, Rejoinders, Responses, Presentation etc. on Public Awareness, Media Relations and other activities are being posted on NPCIL Website on a regular basis to keep public update and informed.

NPCIL is also involved in a number of corporate social activities around the NPP sites. NPCIL also shares information with any member of public on request as a statutory responsibility under Right to information Act, 2005. Also, NPCIL promotes open information system concept for sharing information with the public.

9.4.1 Right to Information

Right to Information Act, 2005 was enacted by the Parliament of Government of India for setting out the practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority. The act was amended suitably by the Parliament with latest revision in the year 2013. NPCIL is a Government of India enterprise and hence the provisions of the act are applicable.

NPCIL being a responsible organisation practices openness and transparency within framework of above and other applicable legal provisions of the country.

9.4.2 Open information system concept

In general NPCIL has web based information system, where the information about NPPs is available. In addition Citizens are free to post questions about NPP and prompt information is provided. Citizens are also free to request visit to any NPP and NPCIL arranges the visit to NPPs and provides necessary information to the visitors with link at web address, http://www.npcil.net/npcil/main/knowmore_Nuclear_Power.aspx.

9.5 INTERNATIONAL PEER REVIEWS

NPCIL is committed to international peer review of all its NPPs to bring home learning opportunities from international peers. The details on such reviews are as follows:

9.5.1 WANO Peer Reviews

NPCIL is one of the founder members of World Association of Nuclear Operators (WANO) and has been actively participating in all its programmes like Operating Experience, Peer Review, Professional & Technical Development Programme (workshops, seminars) and Technical Support & Exchange of good practices, performance indicators, technical support missions.

Being committed to international peer review programme of all its NPPs, NPCIL first invited WANO Peer Review team in 1998 to one of its plants. Since then, first and second round of WANO peer review have been completed for all the operating NPPs in India and third round is also completed in some NPPs and planned to be taken up for remaining ones. NPCIL was the first member under WANO Tokyo Centre, which invited WANO Pre-Startup Review team for its construction plant in 2006. So far WANO Pre-Startup review of its four plants at construction stage has been completed including KKNPP Unit 1. In the year 2015, Corporate Peer Review of NPCIL was carried out by WANO. The purpose of the review was to assess the effectiveness of the support provided by the corporate office to stations for ensuring safety and reliability. In addition, in the past few years WANO has introduced follow-up review in between the WANO peer reviews to follow-up the status of actions taken by the stations to address the areas for improvements identified during WANO peer reviews.

About 150 engineers of NPCIL have undergone Standard Peer Review Training conducted by WANO. NPCIL has provided the services of about 60 reviewers to WANO to support its Peer Review programme. The bar chart shown below is indicative of WANO Peer Review, Pre-Start-up Review, Follow-up Review and Corporate Peer Review of NPCIL plants since 2010.

Figure - 2 : WANO Peer Review of NPCIL stations

Table - 3 : WANO Peer Review of NPCIL stations

2010	2011	2012	2013	2014	2015
KGS-1&2	TAPS-1&2 RAPS-5&6 KK-1	MAPS KGS-3&4	KAPS	NAPS KGS-3&4 RAPS-5&6	RAPS-2 RAPS-3&4 TAPS-3&4 MAPS KAPS NPCIL

9.5.2 IAEA OSART Mission

Government of India invited IAEA OSART mission in 2012, as per the commitment made during IAEA general conference in 2011, for the peer review of Rajasthan Atomic Power Station 3&4 (RAPS-3&4) of NPCIL. The OSART mission was completed in November 2012. The OSART team identified a number of good practices of the plant and also made recommendations and suggestions related to areas where operations of RAPS-3&4 could be further reinforced. A comprehensive action plan for addressing all the identified recommendations and suggestions was drawn up by RAPS-3&4 and actions initiated to address them. A follow-up OSART mission was carried out in February 2014, in which the team noted that action on most of the recommendations and suggestions have been completed and for the remaining ones the action was in progress. OSART team made assessment about the percentage of action completed and observed that 79% of the actions had been completed.

9.6 SHARING INFORMATION INTERNATIONALLY

NPCIL has been sharing information internationally by active participation in operating experience programme of WANO, COG and other international organisations; participation in international meetings and workshops; participation in technical exchange visits.

i. Operating experience

Event sharing under operating experience programme of WANO supports prompt information exchange so as to learn from each other and eliminate recurrence of events. On an average NPCIL shares about 40 events in a year having lessons to be learnt. Following chart demonstrates the sharing of events in the recent past:

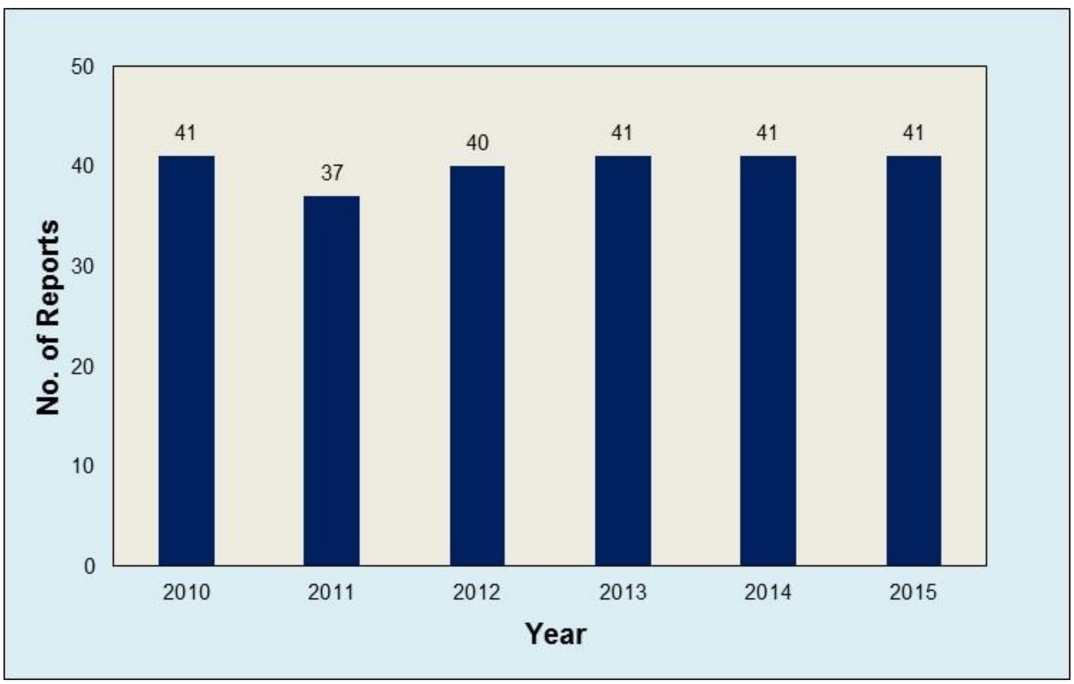


Figure - 3 : Operating Experience Reports submitted to WANO

Also, a Head Quarter Instruction (HQI) has been issued by NPCIL Corporate Office to guide the stations in implementing OE programme. Each station has an Operating Experience Review Committee (OERC) which periodically reviews and discusses the OE information. The implementation status of the OERC recommendations is regularly monitored.

NPCIL fulfils its international obligation of OE sharing and thus promoting global nuclear safety across the world by periodically sending the event reports of its plants to WANO in the standard event reporting formats. These reports bring out the root cause of the events and the lessons learnt which may be useful to other plants.

ii. Performance indicators

NPCIL shares all the WANO performance indicators (PI) data through web based data entry system of WANO with all the operating NPPs of the world. The PI programme provides opportunities to improve safety and reliability of our NPPs. All performance indicators are shared on quarterly basis with WANO and industry. While NPCIL shares with nuclear industry performance indicators of NPPs, it also utilises this programme for benchmarking the indicators with nuclear industry elsewhere in the world to support long term improvement in safety and reliability.

iii. WANO Meetings, workshops and seminars

NPCIL has been deputing its officials for participating in various workshops, seminars and training courses conducted by WANO. The above programmes provide a forum for exchange of information on wide ranging topics in the field of nuclear power production, its safety and reliability.

iv. Technical Exchange Visits

Technical Exchange visits provide an opportunity to exchange information between various NPPs and WANO helps in establishing the first contact between the host and visiting NPPs. First such exchange visit in the world was from MAPS, Kalpakkam to a plant in Moscow region. Technical agenda of the exchange visit is set with mutual consultation between host plant and visiting plant. Under this programme, NPCIL team of experts has visited several NPPs in countries like South Korea, Argentina, China, Ukraine, Romania, Russia, Canada and USA.

Teams from other countries have also made visits to NPCIL plants. These visits have been very useful as NPCIL teams could discuss various issues related to plant operations, safety and operating experience.

v. Sharing information with CANDU Owners Group (COG)

NPCIL is active member of COG and event reports are shared among PHWR operators providing focused exchange of information. NPCIL is also member of industry team formed by COG post Fukushima.

vi. Sharing information with IAEA PRIS

NPCIL has been regularly sharing information with IAEA for its Power Reactor Information System (PRIS). Information which is shared with PRIS include energy generation, energy loss (planned, unplanned, external etc.), outages with outage codes, net electricity generation in India from all sources including nuclear, energy supply for non-electrical applications, information about reactors in operation, under construction or planning stage, etc.

vii. Sharing information with Nuclear Energy Agency (NEA)

NPCIL has been participating in the meetings conducted by Nuclear Energy Agency (NEA) by nominating its experts as a member of various Working Groups and projects under the OECD / NEA.

9.7 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

The responsibility for the design, construction, operation and maintenance of NPP for producing electrical energy in a safe manner has been assigned only to Government Companies. ‘Atomic Energy (Radiation Protection) Rules, 2004’, the AERB Safety Code, AERB/SC/G, on

"Regulation of Nuclear and Radiation Facilities" and AERB Safety Code on Nuclear Power Plant Operation (AERB/NPP/SC/O) clearly assign the responsibility of safety to the licence holder and spell out the obligations of the licensee towards safety. AERB through its multi-tier system of review and assessment ensures that the licensee meets its responsibility towards safety. Hence, India complies with the obligations of the Article 9 of the Convention.

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ARTICLE 10: PRIORITY TO SAFETY

Each Contracting Party shall take the appropriate steps to ensure that all organizations engaged in activities directly related to nuclear installations shall establish policies that give due priority to nuclear safety.

10.0 GENERAL

Atomic Energy Regulatory Board (AERB) and the utilities have policies which emphasize priority to safety in all their activities. Adherence to these policies nurtures and maintains the safety culture developed over years of experience.

As described in Article-6, safety enhancement in Indian NPPs has been a continuous process. In addition to ensuring adherence to current regulatory requirements for new NPPs, the requirement of periodic safety review brings out the need for safety upgrades in the operating NPPs. Safety assessment were carried out following accidents in nuclear industry that led to safety upgrades in Indian NPPs. Safety enhancements arising out of review carried out post-Fukushima accident were covered in the Indian National Report to the second extraordinary meeting and the sixth review meeting of the Convention. Article-6 includes update on Fukushima related modifications in all Indian NPPs and the actions being taken following the coolant channel leaks in KAPS.

10.1 REGULATORY REQUIREMENTS TO PRIORITIZE SAFETY

The Atomic Energy Act 1962 has a separate section which deals with safety and specify the requirements with respect to ensuring safety in all activities involving generation and use of nuclear energy and radiation. This section specifically includes the provisions for safety requirements, prohibitions, regulatory mechanism, including inspection and enforcements as well as initiating penal actions. Further, these aspects are further elaborated in Atomic Energy (Radiation Protection) Rules, 2004 and the Atomic Energy (Safe Disposal of Radioactive Waste), Rules 1987. AERB has been given the powers to exercise these provisions. With its mandate, AERB has formulated Safety Codes and Standards specifying detailed requirements for siting, design, construction, commissioning and operation of NPPs. Safety codes establish the objectives and set minimum requirements that shall be fulfilled to provide adequate assurance for safety. The mandate assigned to AERB is that of safety regulation and no responsibility assigned to it is in conflict with its regulatory role.

AERB Safety Code on ‘Quality Assurance in Nuclear Power Plants’ [AERB/NPP/SC/QA, Rev.1:2009] provides basic requirements to be adopted for establishing and implementing quality assurance programme for assuring safety. Utility Management shall determine its effectiveness in establishing, promoting and achieving objectives of nuclear safety’

The mainstay of India’s nuclear power programme has been the Pressurized Heavy Water Reactor (PHWR) technology. Design of these reactors is governed by AERB Safety Code on ‘Design of Pressurized Heavy Water Reactor Based Nuclear Power Plants’ [AERB/NPP-PHWR/SC/D (Rev.1):2009]. These reactors being of indigenous design, NPPs get in-house design support for the entire life cycle. To enhance the power generation capacity, India is in process of setting up Light Water Reactors with foreign collaboration while continuing its own programme of PHWR based reactors and indigenously designed light water based reactors. AERB Safety Code on ‘Design of Light Water Reactor Based Nuclear Power Plants’ [AERB/NPP-LWR/SC/D:2015] requires responsible organization to set up a ‘design authority’ with responsibility for, and the requisite knowledge to maintain, the design integrity and the overall basis for safety of the plant through its life.

These Safety Codes require that the responsible organisation (utility) shall ensure that safety is given highest priority and shall

i. implement all regulatory policies addressing safety
ii. develop and strictly adhere to sound procedures
iii. review, monitor and audit all safety related design aspects on a regular basis.
iv. ensure that safety culture is maintained .
v. implement design features that have been proven in previous equivalent applications. Where a first-of-a-kind design or feature is introduced, safety is to be demonstrated to be adequate through appropriate supporting research and testing.
vi. ensure that a comprehensive safety assessment of the design and subsequent independent verification is carried out.

AERB Safety Code on 'Nuclear Power Plant Operation' [AERB/NPP/SC/O (Rev.1): 2008] which lays down the requirements for safe operation of NPP requires that-

i. The plant management shall meet all the requirements of the code on quality assurance for safety in NPP and shall prepare and put in place a comprehensive quality assurance programme covering all activities, which may affect the of the plant safety.
ii. The management shall inculcate safety culture in plant personnel and develop a policy which gives safety the utmost priority at the plant, overriding the demands of production.
iii. Training shall be oriented to develop safety consciousness and safety culture at all levels of the plant organisation structure.
iv. The management programmes relating to operation review and audit should aim at ensuring that an appropriate safety consciousness and safety culture prevails.

This Safety Code also requires regular and systematic safety assessment of operating NPPs as part of Periodic Safety Review (PSR), wherein comparison of NPP with current safety requirements is made and implementation of necessary corrective actions is identified.

10.2 SAFETY POLICIES AND PROGRAMMES

The safety policies in India are generally in line with IAEA standards IAEA-GSR-Part-1 and the IAEA Fundamental Safety Principles, and are enshrined in legal and regulatory requirements.

The NPPs in India are designed, constructed, operated and maintained by the utilities, which are fully owned by Government of India. Utilities are responsible for design, procurement of manufactured equipment and components, construction, commissioning and operation of NPPs in India and carry out their functions with a commitment to safety and complying to regulatory requirements. Utilities comply with the AERB requirements by issuing and adhering to their safety policies and accord the highest priority to safety in all their activities. Priority to safety is embedded in the vision, core values, mission and objectives of utilities. NPCIL has issued Corporate Nuclear Safety Policy and Corporate Environment Policy. NPPs under operation have issued station level policies, covering both nuclear and conventional safety aspects. Similarly, Occupational Health & Safety Policy issued by BHAVINI gives importance to safety.

Utilities ensure that the consultants and contractors that carry out assignments and activities also follow the safety and quality assurance norms of the utility. Utilities have management systems in place to ensure that safety is accorded priority in its activities.

The management of NPCIL that owns and operates all the currently operating NPPs accords utmost importance to Nuclear, Radiological, Industrial and Environmental Safety overriding the demands of production or project schedules by

- maintaining high standard for safety within plant as well as in the surrounding areas
- ensuring that health, safety and environmental factors are properly assessed for all NPPs
- ensuring that all employees, contractors, transporters working for NPPs adhere to safety requirements while carrying out their responsibilities
- keeping the public at large informed about the safety standards and regulatory practices that are being adopted at NPPs

Each NPP ensures that their work place is safe and their employees including that of contractor's adopt safe working procedures. Individual units also ensure that they have effective on-site and off-site emergency plans, which are implemented and rehearsed periodically so that in the unlikely event of any accident, the impact on the public and environment is minimized. Some of the important activities for implementation of safety policies are

- Setting up targets for safety performance parameters and their periodic monitoring.
- Carrying out safety audits and reviews at different levels viz. Internal, corporate, regulatory and international like WANO peer review and IAEA OSART mission.
- Assessment and enhancement of safety culture.

All Indian NPPs are ISO-14001(Environmental Management System) and IS-18001 (Occupational Health and Safety Management System) certified. At NPCIL Headquarters, Quality Assurance, Engineering, Procurement, Reactor Safety Analysis, Health Safety & Environment, Research & Development, Knowledge Management, and Information Technology Divisions have obtained ISO-9001: 2008 certification.

Regulatory processes like continuous safety surveillance of NPPs (through review of performance reports, radiological safety aspects, event reports and other routine submissions from NPPs), regulatory inspections, periodic safety review for license renewal, safety culture assessment etc. are employed to oversee arrangements used by the license holder to prioritize safety. In addition, AERB is developing safety performance indicators for measuring performance of the licensees, which are used as inputs for integrated assessment of the licensee's performance.

The Management System of AERB is in compliance with ISO 9001:2008 for consenting, regulatory inspection and development of regulatory documents. AERB's Management System identifies safety as a priority and provides guidance for its promotion and continuous improvement.

For pursuing stated policies, certain general safety principles are followed in all aspects pertaining to NPPs and their regulation.

10.3 GENERAL SAFETY PRINCIPLES

Nuclear installations are designed and operated by keeping the safety objectives as a priority goal. The Codes, Guides and Standards issued by the AERB are the primary documents detailing principles, requirements, practices and policies for safety in design and operation of NPPs. These Codes, Guides and Standards have evolved over years taking into account experience gained from Indian NPPs, relevant documents issued by IAEA and regulatory bodies of other countries.

The broad concepts of Defence-in-Depth and ALARA are the main guiding principles followed in design and operation of plants.

The Management Systems / Quality Assurance practices as detailed in chapter on Article 13, assure that the safety requirements are implemented and adhered to during design, construction, operation and maintenance.

In general, the safety principles, practices and procedures are adhered to during various phases of NPP and are described in the following sub-sections:

10.3.1 Siting of NPP

Siting being the first phase in setting up NPP, safety practices in this phase include

i. Rigorous assessment of design basis for external events.

ii. Considerations for exceedance of design basis.

iii. Graded dose criteria defined for different plant states correlating with requirements for countermeasures and avoiding long term off site contamination

iv. determine the adequacy of protection of the nuclear power plant against internal and external hazards as part of periodic safety review

Consideration of natural and human induced hazards during siting of NPP and in the entire lifetime is covered in Chapter-17.

10.3.2 Design, Construction & Commissioning of NPP

All through the process of design, manufacturing, construction and commissioning the QA systems (refer chapter on Article 13) are implemented effectively to assure that safety principles are given highest priority. These processes are indicated below:

i. A thorough and systematic approach is followed in the design, review and approval in line with applicable quality requirements.

ii. Safety design criteria defined in the different design documents are reviewed and approved by AERB. The safety design criteria also take into account feedback from the operating experience. The design is based on National and International codes and guides.

iii. The detailed safety design is presented through design notes, design calculations and drawings. QA procedures are followed for preparation, review and approval of all design documents. Proper control is exercised for implementing design changes and 'as-built' drawings are maintained.

iv. At appropriate stage, plant systems are formally handed over from construction group to operations group. This transfer is systematically documented in the form of construction completion certificates and system transfer docket.

v. For each system commissioning procedures are prepared to verify design through individual equipment and integrated tests. During commissioning, base line data is collected for future reference. Commissioning reports for each system are prepared and preserved.

vi. For computer based systems, independent verification and validation is carried out as per AERB safety guide Computer based systems of PHWRs (AERB/SG/D-25).

NPCIL Safety Review Committee on project and design regularly reviews the safety related design documents to ensure that safety principles are adhered to in design. The committee reviews features related to safety in new designs, design changes in already approved safety and safety related systems, the Technical Specifications for Operation which translates the design requirements to safe operating policies, feedback from any safety related event at operating units etc. The reviews also assure that the outcome of regulatory reviews has been effectively considered.

Similarly, Internal Review mechanism has been established for BHAVINI for regular review of the design safety aspects of PFBR project.

10.3.3 NPP Operation

The NPP operations are governed by safety policies, safety culture and the good operating practices with the following elements:

i. In the normal operation regime, ALARA is the governing principle. Dose limits for normal plant operation are specified by AERB which are in line with ICRP recommendations.
ii. The limits specified in the Technical Specifications for Operation are approved by AERB. Adequate margins between safety limits and operating parameters are maintained by appropriate interlocks and administrative measures.
iii. NPP is operated by qualified and licensed staff only. The license to operating personnel is issued by following a well-established procedure approved by AERB.
iv. Annual Collective radiation dose budgets for normal operation and for special maintenance campaigns are prepared by NPPs and approved by AERB after multi-tier review. As a part of regulatory review, compliance to approved dose budget is ensured.
v. Equipment and instruments are subjected to regular surveillance as per the frequency defined in Technical Specifications for Operation and other governing documents.
vi. In-service inspection is carried out according to the approved ISI document at all NPPs.
vii. NPPs are periodically subjected to corporate safety audit, regulatory inspection and peer reviews.
viii. NPP operation, incidents and safety issues are reviewed by Station Operation Review Committee (SORC) at NPP level. The station management keeps AERB informed of the outcome of these reviews. Submissions made by NPP for regulatory clearances are first reviewed by this committee and then by Safety Review Committee (Operations) at the Corporate office of NPCIL.
ix. For all significant events, root cause analysis is carried out.
x. For non-standard jobs involving safety, special procedures are made and regulatory approval is obtained. Appropriate mock ups are also carried out wherever necessary.
xi. The Station Health Physics Unit maintains a close watch on radiological status and events at plant and submits periodic report to AERB (refer chapter on Article 15).

The QA group and the Technical Audit Engineer at NPP gives independent feedback to the station management on operation and maintenance of plant. NPCIL's corporate QA group also conducts periodic audits. Each station is subjected to a corporate peer review conducted by a team constituted by corporate office drawn from other stations owned by NPCIL. This review is carried out once every three years for each NPP. In addition NPCIL stations also undergo WANO peer reviews.

Well-defined procedures exist within NPCIL which address issues related to safe operation. These are detailed below:

i. The normal plant operation is governed by Technical Specifications for Operation, which is approved by AERB. The Limiting Conditions of Operation (LCO) for various systems and their surveillance frequency are a part of the Technical Specification. Protection system actuation set points are defined through Limiting Safety System Settings (LSSS) and the set points are tested as per frequency defined in Technical Specification for operation. In addition Safety Limits are specified in Technical Specifications. Further, fall back actions and countermeasures are also defined in case normal configuration of certain redundant equipment is not met for a predefined limited period. For routine operations, NPPs maintain Operating Procedures cum Check Lists (OPCC), Maintenance Procedures, Operating Instructions, QA Procedures, ISI Procedures etc.

ii. Event based Emergency Operating Procedures (EOPs) for internal and external events are prepared for NPPs. These EOPs are part of control room operator licensing and to the extent practical are implemented on simulators for training purposes. Symptom based EOPs have been prepared and are under implementation.

iii. The Emergency Preparedness and Response Plans for both On-site and Off-site emergencies are available at all NPPs. Emergency exercises are carried out routinely to ensure the adequacy of these plans. (refer chapter on Article 16).

10.4 SAFETY PRINCIPLES OF AERB

AERB is entrusted with the responsibility for regulating activities related to safety in nuclear installations. The safety principles followed by AERB are as follows:

i. Permits activities according to the mandate given to it, through a consenting process. AERB stipulates and enforces the conditions of consent.

ii. Develops safety standards, codes and guides taking into account the Indian conditions, requirements for the country, recommendations of international organisations and the best practices of other countries.

iii. Encourages compliance to safety guides but accepts other approaches if safety objectives and requirements can be met.

iv. Adopts the principle of “management by exception” following a graded approach through a system of safety committees where issues of greater safety significance are given consideration in higher-level safety committees for resolution.

v. Encourages self-regulation by the licensee.

vi. Considers licensee as a partner in safety and extends all necessary assistance in the interest of safety, where appropriate.

vii. Invites participation of utilities in the regulatory process.

viii. Conducts periodic inspections of NPPs and channels its resources according to the safety performance of the licensee.

ix. Encourages licensee to achieve high level of safety culture.

x. Learns from the experience feedback and adapts to improve its functioning and effectiveness.

xi. Conducts its activities in an open and transparent manner.

AERB carries out a multi-tier review for the new and operating NPPs through a system of safety review committees (refer chapter on Article 14). The activities of siting, design, construction, commissioning, operation and related regulatory consents follow procedures and policies prioritizing safety.

AERB has established graded approach for regulatory functions. The staff at AERB is being involved in effective implementation of graded approach and detailed guidelines in this respect are being formulated.

10.5 SAFETY CULTURE AND ITS DEVELOPMENT

All nuclear power stations of NPCIL have established safety culture assessment and fostering system in accordance with the requirements of NPCIL HQI titled ‘Assessment and Fostering of Safety Culture at Nuclear Power Stations’ [NPCIL Head Quarter Instruction no. 0559]. The system involves both safety culture assessment based on documented data in the station and safety culture survey.

As a part of this system, each station carries out following activities.

- Evaluation of various safety culture process inputs by Safety Culture Assessment Panel (SCAP) members independently against the set criterion.
- Conducting quarterly review of outcome of the said evaluation process by SCAP members jointly to identify significant safety culture issues and corrective actions to address them.
- Conducting annual safety culture survey
- Review of safety culture survey results by SCAP
- Overall assessment of safety culture annually by station management and issuing corrective action program.

The above process is supported by training and effective top down and bottom up communication at the station.

The utility headquarters oversee the functioning of the system at all stations and supports stations as required. AERB recognizes the importance of promotion of safety culture in utility and within AERB staff. The requirements for establishing safety culture within utility have been spelt out in the regulatory documents of AERB.

The review and assessment of the safety culture is part of AERB's safety monitoring and review mechanisms and is also done during periodic renewal of operating license. Events occurring at the nuclear installations, findings of regulatory inspection and management response to events and regulatory recommendations, implementation of operational experience feedback, trends in radiological performances, participation of AERB in licensing interviews of control room staff and plant management give a picture of the safety culture prevailing at the NPP.

AERB has initiated a process for assessing the safety culture of itself and NPPs. Currently such assessments are being done on annual basis. Based on the safety culture assessments, management actions are taken. For safety culture assessment of NPPs, Safety Culture assessment system is being developed to inspect and recognize early symptoms/signs of declining safety culture of the utilities. Safety Culture attributes adopted from the international guidelines and modified to suit the AERB requirements. Regulatory inspection findings are mapped on these attributes in order to evaluate the safety culture of NPPs. The outcome of the assessment is taken into considerations in regulatory decision making and regulatory oversight is sensitised in case degradation in safety culture is observed.

Arrangements for safety management, safety monitoring and self-assessment, independent safety assessments are elaborated in chapter on Article 14 (Assessment and Verification of Safety).

10.6 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

Safety is given overriding priority by all organisations engaged in activities directly related to nuclear installation. AERB and utilities have stated safety policies that give utmost priority to nuclear safety. Principles, practices, procedures and the review mechanisms adopted towards meeting the objectives of these policies ensure that safety is given an overriding priority in all the activities related to safe operation of NPPs. Therefore, India complies with the obligations in the Article 10 of the Convention.

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ARTICLE 11: FINANCIAL AND HUMAN RESOURCES

1. Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.

2. Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life.

11.0 GENERAL

This chapter describes ‘Financial and Human Resources’ of the utilities. The resources of AERB are described in Chapter on Article 8: Regulatory Body.

11.1 FINANCIAL RESOURCES

The Nuclear Power Corporation of India Limited (NPCIL) is a Public Sector Enterprise under the administrative control of the Department of Atomic Energy (DAE) of Government of India. NPCIL was formed in September 1987 by converting the erstwhile Nuclear Power Board, a Central Government department into a government owned corporation in accordance with the provisions of Atomic Energy Act-1962. At the time of formation of NPCIL, all the assets (except the first unit of Rajasthan Atomic Power Station RAPS–1) were taken over by NPCIL. RAPS-1 has been retained as a Government owned unit, being managed by NPCIL on behalf of the Government. The main objective of the company has been to increase nuclear power generation capacity in the country, consistent with available resources in a safe and economical manner in keeping with the growth of energy demand in the country.

NPPs under construction and operation were fully funded by Government of India earlier. The formation of NPCIL facilitated operational flexibility and the ability to borrow capital from the market so that the financial resource base can be increased to step up the nuclear power programme.

NPCIL is a wholly owned company of Government of India and is registered under Indian Companies Act-1956. The company has a fully subscribed and paid up share capital of ₹101743 Million. The company has reserves in excess of about ₹199687 Million. The gross block of the company at its inception (comprising of TAPS - 1&2, RAPS - 2 and MAPS - 1&2, totaling 960 MW) was only ₹4480 Million which has now grown to (5680 MW excluding RAPS-1) about ₹332626 Million as on end March 2015. NPCIL is a profit making company and has been paying annual dividends of the order of 20% to 30% to the Government of India.

The financial resources of NPCIL come from budgetary support from Government of India, borrowings from capital market and internal surpluses. NPCIL raises finances for the construction of new projects through a combination of Government budgetary support, market borrowings (in the form of short term and long term debt instruments) and internally generated resources by sale of electricity. The expenditure towards safety improvements in the NPPs throughout its lifetime are met through internal resources generated by NPCIL. Adequate financial discipline and prudence are exercised in borrowing money from the market. Gestation periods of the projects are progressively optimized so as to keep financing cost including interest during construction, at a reasonable level. Due diligence is exercised about debt obligations and there is no default in repayment of principal and/or interest. The credit rating of NPCIL by agencies like CRISIL, CARE, is AAA denoting the highest safety, which helps the company to borrow money from the capital market at the most competitive rates.

BHAVINI is a fully owned Enterprise of Government of India. Mandate of BHAVINI is to construct, commission and operate the first 500 MWe PFBR at Kalpakkam in Tamil Nadu and follow it up with future Fast Breeder Reactors. The government has financed 76% of the cost of PFBR through equity, 4% equity has come from NPCIL and remaining 20% has been obtained as government loan.

11.1.1 Operation and Maintenance

NPCIL, as the owner of NPPs has the obligation to provide adequate finances for operating the nuclear power plants in a safe manner to meet the requirements of AERB and its own mission.

NPCIL generates its revenue primarily by sale of electricity. Its present annual revenue is typically ₹92631 Million. In line with the provisions of the Atomic Energy Act 1962, the tariff for electricity from each station of NPCIL is notified by DAE in consultation with Central Electricity Authority. The parameters such as the capital cost, the market borrowings, input costs are factored into arriving at the various components of tariff.

NPCIL sells its electricity to 30 State Electricity Boards (SEBs) / distribution companies primarily located in Northern, Western and Southern regions of the country. The monthly invoices based on the approved tariff along with the fuel price variation adjustment are raised on State Electricity Companies at the end of the month based on the metering done by the system operator and accounted for by the Regional Power Committee. The State Electricity Companies hold a revolving letter of credit in favour of NPCIL for their monthly power invoices and payments are received during the subsequent month.

The Operation and Maintenance (O&M) expenditure for each station is budgeted every year. It is being funded by internal resources generated by the NPCIL every year. In addition, whenever it is necessary to finance any major works/purchase or replacement of major components, the resources are raised through borrowings or from internal surplus/ budgetary support as appropriate. Since the tariff is similar to the principle of cost plus basis, O&M expenditures are covered through tariff in addition to recovering the capital charges such as giving a return on equity capital and providing depreciation subject to the units operating at normative capacity factors. The internal surpluses are deployed for the nuclear power plants in operation as may be required and for nuclear power projects under construction. The financial resources are budgeted on a yearly basis and in five-year plans. Adequate financial planning and forecasting is done for the complete life of the plant to ensure availability of financial resources throughout the life of the plant. Thus there is no constraint, either existing or foreseen, on financial resources for the safe operation and maintenance of the NPPs

In accordance with the Disaster Management Act, 2005, the responsibilities for handling off site radiological emergencies have been assigned to the state and central government agencies and further elaborated in the EPR plans (Refer Chapter 16). The Civil Liability for Nuclear damage Act enacted in the year 2010 provides for prompt compensation to the victims of nuclear incident through a no fault liability regime channeling liability to the operator. Pursuant to the Civil Liability for Nuclear Damage Act, 2010, the Nuclear Liability Fund Rules, 2015 have been promulgated. The rules establish a Nuclear Liability Fund which comprises the levy collected from operators of nuclear installations. .

11.1.2 Renovation and Modernization (R&M)

R&M activities for NPPs in operation are of two types. The first involves routine replacement of operation and safety related components and equipment based on their performance requirements in which expenditure is relatively small. Expenditure on this type is met through the revenue budget of the respective stations and is covered by the tariff as part of O&M

expenditure. The second type involves funding for any major safety up-gradations in line with the regulatory requirements generally based on a PSR or based on operating experience feedback both national/international events or refurbishment of the major components of the plant because of operation requirements or technological obsolescence (R&M activities are brought out in chapter on Article-6). Such activities involve shut down of reactor for extended periods of time and involve major expenditure.

Recognizing that renovation and modernization activities would entail major expenditure, a renovation and modernization levy of about 5 paise per kWhr was started in the year 1996 primarily with the intent of carrying out the renovation and modernization of older generation reactors. The money collected through R&M levy was kept in a committed reserve account. R&M levy was started in 1996 and after accumulating adequate reserves, the same was stopped from 1st December 2003. Situation will be reviewed from time to time, taking into account the adequacy of resources available with the corporation. In case, in future, the reserves are found to be inadequate, the consumers of electricity (SEBs) who are already familiar with concept, may be approached for its re-introduction.

A holistic analysis on expenditure and resource mobilization in regard to all the units in operation is carried out by NPCIL Corporate Office by proper financial planning, monitoring and resource mobilization.

11.1.3 Decommissioning and Waste Management

The commercial life of NPP has been taken as 25 years. With improvements in design methodologies and better understanding of safety margins, retrofitting, better materials and equipment, the reactors can now operate safely for much longer periods of 40 to 60 years.

Out of the 21 operating nuclear power reactors, the two boiling water reactors at Tarapur are the oldest. They were commissioned in the year 1969 and have been progressively retrofitted. Similarly, the PHWR based NPPs have been undergoing renovation and modernization programmes. In this connection, En-masse Coolant Channel Replacement (EMCCR) and En-masse Feeder Replacements and necessary safety up-gradations of RAPS-2, MAPS-1&2, NAPS 1&2 and KAPS-1 have been completed as applicable. These major jobs have given a very good insight of technical capabilities and financial requirements for decommissioning.

Realizing the quantum of financial resources that will be required in future for de-commissioning of reactors, a de-commissioning levy at the rate of 2 paise per KWhr is being collected as part of tariff. The present de-commissioning levy has been calculated to take care of de-commissioning expenses. The provisions in this regard will be reviewed in future, based on experience and technological development. Tariff of Nuclear Power Plants in India is fixed once in every 5 years. In future the levy could be revised if need arises through such reviews.

Routine radioactive waste management during the operation of the NPPs is included as part of the O&M expenses. Since Indian energy security policy necessitates adoption of the closed nuclear fuel cycle, the fuel is considered as the property of the Government. The spent fuel from the first stage is taken by the Government from NPCIL either for reprocessing or for storage as necessary for the subsequent stages of the programme. The re-processing of spent fuel and the associated waste management are carried out by the Central Government.

11.2 HUMAN RESOURCES

Availability of qualified and trained manpower for the nuclear power programme has been one of the greatest strengths in India. Realizing the importance of qualified and trained manpower, DAE started Human Resource Development programme in early 1950s, well before the launching of nuclear power programme in the country. A training school at Bhabha Atomic Research Centre

(BARC) was established in August 1957. University qualified engineers and science graduates are recruited on an annual basis and are trained in the BARC Training schools, premier institutes for training in nuclear science and technology through one-year rigorous training course including theoretical and practical aspects of nuclear engineering and sciences. Subsequently when the training needs for the operating nuclear power stations arose, the Nuclear Training Centres (NTCs) have also been set up at the NPP sites. The core of the manpower for the nuclear power programme comes through these training centres. These personnel had also the benefit of experience in the construction and operation of the research reactors. In addition, experienced manpower from conventional power and industry are inducted.

The country's universities, engineering diploma institutes and industrial training Institutes form the basic educational infrastructure from which engineers/scientists, technicians and skilled tradesmen are recruited and subsequently trained to suit the job needs.

Networking with the Indian Institutes of Technology has been strengthened and post-graduate courses in nuclear engineering have been started at several institutes. Sponsored post-graduate program called 'DAE Graduate Fellowship Scheme' were started at all the IITs. Board of Research in Nuclear Sciences (BRNS) under DAE provides another avenue for networking by sponsoring research projects in the field of Nuclear Science and Engineering at various educational institutes. 'Homi Bhabha National Institute' established under DAE pursues post-graduation and PhD programs in areas of nuclear science and technology.

Dedicated Knowledge Management groups have been set up in all organisations of the DAE to pool and disseminate the available knowledge base and further augment knowledge base to meet the challenges of the future. Engineers and scientists of BARC and NPCIL participate in several international training programmes conducted by the IAEA and other organisations to further enrich their capabilities.

11.2.1 Arrangements and Regulatory Requirements for Human Resources at NPPs

NPCIL's technical manpower includes engineering graduates from prestigious engineering colleges/universities in the country. Freshly recruited engineers go through one year of training in DAE/BARC Training School or in Nuclear Training Centres of NPCIL. After such training, they are placed at NPCIL Corporate Office for functions like design, QA, procurement etc., or construction sites or operating units based on the needs and suitability for the job. While persons appointed at NPCIL Corporate Office are encouraged to do M.Tech / MBA course in their areas of specialization, those at plant sites are regularly/periodically trained for taking up higher responsibilities. They undergo licensing/ qualification examination before they are actually assigned the higher responsibility. In addition, NPCIL also carries out direct recruitment. Engineering diploma holders with 3-4 years of Diploma Course in Engineering (after High School ,10+2) conducted by the polytechnic institutions and technicians with two year industrial training after high school, conducted by industrial trade institutes are other levels of recruitment. NPCIL provides challenging work environment and excellent quality of life at its residential colonies. Infrastructure facilities like health, education and transportation are adequately taken care of and recreational facilities are also provided to motivate personnel to continue their career with NPCIL. Off-site support from the NPCIL Corporate Office is provided to NPPs based on requirement. During the past three years NPCIL has recruited 721 Scientific and Technical personnel at various levels and the staff strength of NPCIL as on December 31, 2015 was 11372.

The initial manpower required for construction, commissioning and operation of the Prototype Fast Breeder Reactor has been inducted from NPCIL and IGCAR. BHAVINI has also undertaken recruitment of graduate engineers and staff at various grades. IGCAR training centre will cater to training needs for Fast Reactors. The operation staff is currently in training at IGCAR, NPCIL plants and preparatory activities for commissioning of the PFBR. The qualification and licensing of the staff will be in line with the norms established by AERB for operation of PFBR.

The assessment of the demand for recruitment of the manpower for the projected growth of nuclear power generation capacity generally starts with the clearances obtained for the new projects. It is pertinent to mention that since the nuclear power programme in the country has been a continuous one and the structured recruitment and training programme has always kept pace with the requirement. With the availability of large number of science and technology institutes in the country, the supply constraints are not likely to be faced for the projected growth of the nuclear power programme. In addition to the above, the country also has a large pool of retired experts in nuclear science, whose services are frequently utilised for specific areas of the nuclear power programme.

The Radiation Protection Rules (2004) and AERB regulatory documents give the requirements regarding the qualification, training and retraining of personnel working in the radiation areas. The regulatory requirements for staffing, qualification, training and retraining of staff for NPPs are given in AERB safety Code, on 'Safety in Nuclear Power Plant in Operation' (AERB/SC/O, Rev.1): 2008 and AERB Safety Guide, on 'Staffing Recruitment, Training, Qualification & Certification of Operating Personnel of NPPs' AERB/SG/O-1.

11.2.2 Competence Requirements and Training Needs of NPP Personnel

Detailed procedures for staffing, qualification, training and retraining of staff for NPPs are approved by AERB. The operating station organization of a typical Indian NPP has six levels (Management Level and Level I to Level V) in five major functions viz. Operation, Maintenance, Quality Assurance, Technical Services, Health Physics and Training functions. Level-I, II &III control room positions are for Shift Charge Engineer (SCE), Assistant Shift Charge Engineer (ASCE) and Control Engineer respectively. These positions for operation and fuel handling operations require licensing through a procedure approved by AERB. Operations personnel normally working in field (levels IV, V) are certified by the plant management. Special training procedures are established and being followed before deputing the contract workers in NPPs.

NPCIL has qualified and trained manpower meeting the job requirements at all levels, be it technicians, scientific assistants or engineers and scientists. The staff strength of NPCIL as on 31st March 2016 was 11372 out of which 9516 belong to technical and scientific cadre. Competence requirements and training needs of all key persons are ensured before they are deployed for carrying out the safety related activities in nuclear installations

The Corporate Training group focuses on development of trainers and training systems using SAT (Systematic Approach to Training) methodology. Various NTCs implement orientation-training programmes for each category i.e. engineers, scientific assistants and technicians, recruited as trainees based on approved recruitment and selection procedure. The course contents and other administrative guidelines for initial and retraining have been established for each category of employee. NTCs are equipped with necessary infrastructure for implementing the courses as per approved syllabi. Based on Job-Task-Analysis, tasks for each position have been defined and a performance oriented checklist against each task is developed for effective assessment of On-Job training. The Corporate Training group is responsible for ensuring uniform standards of training at each training centre by developing guidelines for orientation training programme. For ensuring uniform standards of assessment, licensing examinations are coordinated by the corporate office.

Around 100 training officers are posted in all the training centres to look after the initial induction training, qualification and re-training requirements at stations. Additionally, for imparting training in a specific field / area, experts from stations, as well as other organisations including

AERB are invited. The trainers have operation and maintenance experience. Some of the trainers are licensed control room operators who also provide training on simulators.

A total financial resource of approximately 2% of the revenue budget is allocated to all training centres in NPCIL towards training, qualification, re-training and training infrastructure requirement.

11.2.3 Training of Operations Staff

The training and licensing scheme of the operating staff is as per AERB requirement. Presently, NPCIL has eight Training Centres, where graduate engineers and technicians are trained. NPCIL has full-scope training simulators at RAPS, KGS, TAPS-3&4 and KKNPP. These training simulators provide necessary training to the operating personnel.

11.2.3.1Induction and Initial Training

This ensures completion of entry-level competency requirement to enter certification stage of licensing / qualification.

i. Academic Qualification and Experience

The personnel occupying positions at level I, II and III need to be graduate engineers with relevant work experience of 8, 6 and 3 years respectively. Those who are diploma in engineering can occupy positions at level III and IV after having relevant work experience of 9 and 4 years respectively. Similarly, requirements have been established for personnel occupying level IV & V from other streams of education.

ii. Training

Successful completion of' appropriate Orientation Training programs of 1, 1½ and 2 years duration is an essential entry Level pre-requisite for those entering directly at Level- III, IV & V respectively. Training mainly focuses on providing sound foundation on nuclear reactor fundamentals, a typical station specific equipment and system knowledge, training towards 'nuclear and industrial' safety, radiation protection, radiation emergency preparedness and work controls.

11.2.3.2 Licensing, Qualification and Certification Programme

i. Authorisation Based Training

After completing the initial training, a candidate is required to complete the authorisation based training programs such as Radiation Protection Training, Station Protection Code (SPC) and Electrical Authorisation. Successful completion of these authorization based training is mandatory before taking up final certification examinations.

ii. On Job Training

To gain the job experience and ensure the required competencies of the incumbent for the job, task based checklists are developed for Level – III, IV and V. If a task could not be performed on plant systems/ equipment due to lack of opportunity, alternate methods like performance on simulator or on mock-up or through technical discussions including enactment of the procedure (virtual conduct of the task) is to be deployed. Those due to acquire first time license at level-III should have acquired minimum of three months of control room experience under supervision after completion of eighteen month on job training and should have participated in at least one start-up / shut down activity at the plant.

iii. Simulator Training

Simulator training mainly provides experiential learning of control room operation. Training is based on the approved guidelines for normal operations i.e. start-ups / shutdowns, handling of anticipated operational occurrences (AOOs) and emergency operating procedures (EOPs) related to main plant. In respect of fuel handling system operations, it provides necessary practice of safe Fuel Handling operation and handling of AOOs. In the absence of plant simulator at a plant, the requirement of simulator training is met by providing training at a simulator located at a plant having similar design (refer para 11.2.4).

iv. Licensing / Certification Stage

Licensing examinations for Level-III and II for Main plant / Fuel Handling (FH) operation personnel are conducted under the control of NPCIL Corporate Office. Prior to this, walkthrough for these personnel is conducted under plant management control. The last stage of verification is final assessment interview for medically fit candidates, conducted under AERB control for Level-III, II and I for main plant, Level-III, and II for FH operation personnel. Qualification process (written examination, walkthrough and final assessment interviews) for Level IV &V is done under plant control.

For the first time licensing, candidate has to satisfy all the entry-level requirements as detailed above before appearing for the written examination for levels III & II. The walkthrough test is conducted when a candidate has qualified in all the applicable written examinations and is applicable for Level-II, III. Through this test, the practical knowledge of the candidate is evaluated by a minimum of three field examiners. The evaluation process covers various phases of plant/systems operation covered in the 'walk through' checklist to provide assessment for the candidate's physical, practical and procedural knowledge of Systems, Structure and Components of NPPs.

Medical fitness tests as per approved guidelines are conducted for all candidates appearing for licensing, as a pre-requisite for the final assessment interview.

A candidate after successfully completing the pre-requisites of licensing procedure appears before the Final Assessment Committee. Final Assessment for level–I, II & III position is conducted by a committee constituted by AERB and only after satisfactory performance the candidate is licensed for the given position.

v. Certification

The personnel occupying level-IV & V positions in control room are certified by the plant management and the process of certification is carried out under its control. This task is performed by a Committee constituted by NPCIL.

vi. Management Training for level-1 position

This is an essential entry level pre-requisite for Level-I candidates only and a candidate for Level-I has to successfully complete the 'Management Training' programs such as Codes and Guides of regulatory body, Quality Assurance aspects of NPP Operation, Safety culture, Operation Management, Personnel Management, Procedural knowledge related to administration and finance, vigilance and security aspects.

vii. Senior Management Qualification

Senior Management Qualification is covered under specific instructions issued by NPCIL for meeting the regulatory requirements. The aim of this qualification is to assess candidates through written examinations and interviews for their technical knowledge and overview of safety management. AERB qualifies the successful candidate after a final assessment interview conducted by its committee. The management structure at the NPP is included in the Technical specifications for operation approved by AERB. Accordingly any change in management structure has to be reviewed and approved by AERB.

11.2.3.3 Re-training/Re-Licensing Process

i. Re-training Process

The retraining duration for licensed positions is at least four weeks per year during the validity of license. During re-training, efforts are made to train the entire crew together as a team on simulator exercises. The course content covers refresher of fundamentals and safety practices, modifications made in the plants and procedures, Root Cause Analysis, Safety Analysis, good practices and EOPs and simulator retraining/ alternate retraining in lieu of simulator retraining.

ii. Re-Qualification Process

A license / qualification is valid for three years. A candidate needs to be re-licensed/ re-qualified before the last date of validity of the license/ qualification. A person licensed for a particular position can be re-licensed to the same position provided he meets the prerequisites such as medical fitness, Electrical Authorisation and mandatory re-training programs as applicable and is found fit by the final assessment committee.

iii. Re-authorisation Process

Persons absent from the licensed position duty continuously for more than one month are re-authorized after a formal assessment to ensure that they are updated with plant specific changes introduced during the absence with respect to plant modifications, procedural changes, and incidents/events etc.

11.2.4 Plant Simulators

Each Nuclear Power Plant has a training centre. The training centre is for captive use of the station for plant specific training and has a centralized nuclear orientation school for induction training. Advanced training facility such as plant simulators are provided for different technology reactors. These training centres conduct approved training programmes under supervision of corporate training group of NPCIL.

As mentioned earlier, currently there are four full-scope simulators for PHWRs located at RAPS-1&2, RAPS-3&4, KGS and TAPS-3&4. The simulator at RAPS-1&2 caters to imparting training for personnel working in old plants i.e. RAPS-1&2 and MAPS, while the other simulators at RAPS-3&4 and KGS site are based on the design of standardised 220 MWe reactors and cater to the requirements of all the other 220 MWe PHWRs. The fourth located at TAPS-3&4, is based on the design of 540 MWe PHWR. VVER based simulator has been commissioned and is in operation at KKNPP site to take care of the training requirements of 1000 MWe reactors of VVER design. With these simulators, NPCIL is able to provide simulator training to all the operating personnel working in NPPs. In addition, there are three soft panel based Fuel Handling System (FHS) simulators at KGS, RAPS-3&4 and TAPS-3&4 for imparting training in Fuel handling operations.

To ensure effective simulator training, dedicated trainers who are required to maintain their supervisory license (level-II) are deployed to ensure maintenance and effective utilization of the simulator for achieving optimum training.

11.2.5 Training of Maintenance and Technical Support Staff

NPCIL has qualified and trained manpower meeting the job requirements at all levels, be it technicians, scientific assistants or engineers and scientists. Competence requirements and training needs of all key persons are ensured before they are deployed for carrying out the safety related activities in nuclear installations.

Arrangement for initial training, qualification and retraining of maintenance and technical support staff also exists at all NPPs in line with operation staff. By ensuring the maintenance of operational license and qualification of personnel deployed in Technical Services, Training and Quality Assurance sections their rotations have become feasible.

11.2.6 Improvements to Training Programmes

NPCIL regularly organises special training programmes for experienced operation engineers conducted by international organisations like WANO on a variety of topics such as “Operations Decision Making”, “Advanced Simulator Instructor Training”, “Training Effectiveness and its Evaluation” etc. and also provided them opportunity to interact with their peers working in NPPs abroad. Within the organization, workshops are organized to share operating experiences e.g. “Just-In-Time” type operating experiences etc.

Training centres at all NPPs conduct regular training courses and refreshers courses to cover new insights from safety analysis, operating experience, industrial/fire safety, radiological safety and regulatory issues etc. to maintain the personnel competency. Only qualified and licensed trainers along with line managers and experienced operation engineers are maximally utilised to impart training to fresh and experienced operations persons to provide insights to safety analysis and operating experience. Training course material is periodically reviewed to incorporate improvements to training programmes resulting from operational experience, plant modifications and insights from safety analyses. Further the training/ re-training of NPP personnel is enhanced through incorporation of separate module on accident management.

Updated e-training manuals ensure that licensed personnel have easy and assured access of these manuals any time they desire. The training centres are equipped with various mock ups and training aids such as cut-away-view of complex mechanisms e.g. Fuelling machine ram assemblies, separator assemblies, breakers of various types, Control valves etc. Computer based training packages (mostly in-house) are utilized to promote understanding of difficult dynamic devices.

11.2.7 Sufficiency of Staff at Nuclear Installations

Key personnel for O&M are identified and located prior to commencing commissioning operation and the full staff strength is progressively built up. O&M personnel gain valuable experience during commissioning of the Unit. Recruitment, Training and Qualification processes proceed in a planned manner so that the required complement of trained and qualified staff stipulated by AERB guide “Staffing, Recruitment, Training, Qualification and Certification of Operating Personnel of Nuclear Power Plants” (AERB/SG/O-1: 1999) is in position prior to start-up of the unit.

Minimum staff requirements are met as a part of Limiting Conditions of Operation (Technical Specifications for Operation) and any non-compliance may attract the regulatory enforcement. In addition, there is administrative control regarding the minimum number of Senior Managers to be present at site to ensure safety of NPPs. In India, multi-unit sites adopted twin unit station concept in order to leverage its managerial resources while ensuring the availability of dedicated operating staff with regard to safe operation of each unit. The minimum requirement of operating staff for each unit is specified in the AERB approved Technical Specifications of Operation for the respective station. In case of an accident at any of the units, existing staff over there can be augmented from the other unit while ensuring availability of the key staff for its safe operation/shutdown state. The existing arrangement enables the utility to manage a severe accident with existing manpower at a station. If required, the same can be further supplemented with trained manpower available at other similar design NPPs and NPCIL HQ.

11.2.8 Use of Contract Personnel

The contractors' competencies to meet desired task /work requirement is evaluated during pre-qualification of a contractor/vendor agency after which only the agency becomes eligible for submitting tenders documents/offers. Some of the attributes considered for pre-qualification are technical capability, financial status, resources (Man & Machine/Infrastructure back up), Quality assurance organization, safety organization, ISO certification etc. Feedback regarding credentials, past work experience and in-house design capability is also obtained for assessment of contractor's competency.

Contractor's personnel are not allowed to carry out any job without supervision. They are not deployed for carrying out any operations in the control room and vital areas.

Contract personnel have appropriate training and instructions in radiation safety as per the Atomic Energy (Radiation Protection) Rules, 2004 in addition to the appropriate qualification and training required for performing their intended tasks.

11.2.9 Regulatory Review and Control Activities

The training procedure and programmes are subjected to audit by NPCIL corporate office as well as by AERB for verification of adherence to the procedures. For each training & qualification related activity, NPCIL has developed standards/ guidelines in consultation with AERB so as to meet the regulatory standards. Training & retraining, licensing & re-licensing, qualification & re-qualification of the plant personnel are carried out in accordance with the procedures approved by AERB and are described in section 11.2.3 above.

Plant managers also have to acquire management certification based on AERB approved guidelines. The licensing procedure prepared based on regulatory documents provides various standards including the methodology to deal with the exceptions, assumptions etc. The checklists are always kept current through periodic revision.

To facilitate effective re-training to the licensed engineers, as per the regulatory requirement, availability of six crews for shift operation at each station is ensured. This provides uninterrupted opportunity for one crew to undergo training at respective training centres.

11.3 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

Adequate financial resources are available to support the safety of each nuclear installation throughout its life. There is a well-developed system to assess the needs, generate and provide financial resources. The performance of the NPPs, operating base, centralized management, tariff mechanism, credit worthiness of the utility etc. are factors strongly in favour of meeting the obligations of this Article. With regard to human resources, an early start well ahead of the launching of the nuclear power programme has enabled a sound framework to be in place. This apart, systematic development has also been carried out over the years through experience and the evolving needs. The requirements stipulated by AERB through its Codes are quite exhaustive. This has been followed up by the Utility through its own systems and procedures. The necessary training infrastructure has been built to meet the needs. Therefore India complies with the obligations of Article 11 of the Convention.

ARTICLE 12: HUMAN FACTORS

Each Contracting Party shall take the appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation.

12.0 GENERAL

Human and organisational factors have a very important role in assuring safety. Therefore human factors need to be duly accounted while considering siting, design, construction, commissioning and operation of NPPs to ensure that the capabilities and the limitations of human performance are taken into account. Assessment of human and organisational performance is an ongoing process and corresponding improvements are made based on the insights gained.

12.1 REGULATORY REQUIREMENTS

AERB Safety Codes on Design of PHWR based NPPs, AERB/SC/D (Rev.1, 2009) and Design of LWR based NPPs AERB/NPP-LWR/SC/D (Rev-0, 2015) inter-alia establishes the requirements for design for optimised operator performance. This includes the need for designing working areas and environment according to ergonomic principles, a systematic consideration of human factors and the man-machine interface. Safety Guides on Safety Related Instrumentation and Control for Pressurised Heavy Water Reactor Based Nuclear Power Plants (AERB/SG/D-20) and Radiation Protection in Design (AERB/SG/D-12) provide guidance regarding design for optimum human performance. AERB Safety Code on Nuclear Power Plant Operation (AERB/SC/O, Rev.1,2008) gives requirements to reduce the human errors. AERB document on 'Human reliability analysis (methods, data and event studies) for NPPs' (AERB/NPP/TD/O-2) provides various methods and illustrative examples for estimation of human error probabilities.

Organizational factors and managerial aspects have a major impact on the behaviour of individuals. AERB Safety Code on Quality Assurance in NPPs (AERB/SC/QA, Rev1, 2009) covers the managerial commitment to improve human factors to enhance the safety in NPPs. It requires that management shall determine the competence requirements for individuals at all levels and shall provide training or take other actions to achieve the required level of competence.

AERB has identified the significance of consistency in application of regulatory requirements as well as decision making and developed dedicated methodologies/ procedures for various regulatory process for safety oversight.

12.2 HUMAN FACTOR CONSIDERATIONS

12.2.1 Siting

During the siting stage, multi-disciplinary inputs (such as data obtained from geotechnical, meteorological investigations, site seismicity, hydrological studies, epidemiological studies and feasibility of off-site emergency response plan) are obtained from various agencies for site suitability assessment for proposed nuclear installation. Proper organizational arrangements for effective interfaces and assessment of human factors such as competency of personnel performing these investigations/ studies are required to be ensured for acceptable quality of data analyses needed for siting consent. These aspects are addressed in the utility's QA Manual for Siting which is also reviewed by AERB, in addition to Site Evaluation Report (SER), prior to issuance of Siting consent.

12.2.2 Design

The design of systems, structures and components and the plant layout is carried out in accordance with the applicable design codes and guides as stipulated by AERB and prevalent international practices. These are aimed at limiting the effects of human errors during normal operating conditions, transients and during maintenance. The man-machine interface is designed to provide the operators with comprehensive and easily manageable information. Wherever operator actions are required, it is ensured that required information and adequate time are available for taking necessary actions. The control panels are ergonomically designed. Working areas are designed with due consideration for personnel comfort to avoid the human errors. Availability of a training simulator is a mandatory regulatory requirement for licensing of NPP. PSA insights are used to identify situations where human error could have significant contribution to CDF and the efforts are made to reduce them by introducing appropriate design changes.

12.2.3 Operation

The nuclear installations are operated within the limits specified in the technical specifications for operation, reviewed and approved by AERB. To ensure a high degree of quality in operation of an NPP, all control room operators are graduate engineers who are trained and licensed as per the licensing procedures approved by AERB. All activities including surveillance testing are performed using approved procedures to minimize errors due to human factors. All operations in the control room as well as in the field are carried out only after adequate pre-job briefing and planning. Post-job debriefing is done for certain types of jobs to identify the areas of improvement with respect to best practices and taking appropriate actions for enhancing human performance [NPCIL Head Quarter Instruction no. 0548: Conduct of Pre-Job Briefings and Post Job Debriefs]. NPCIL establishes plant configuration control procedures to prevent human errors during outage management, maintenance and implementation of engineering changes[NPCIL Head Quarter Instruction no. 0547:Guidelines for Configuration Management in Operating Stations].Human factors are considered during the design modification as a part of configuration management. Necessary changes in the relevant documents, training and O&M procedures are carried out after every modification subjected to appropriate review and approvals.

12.2.4 Training

Training of staff for normal and off-normal operating conditions on full scope simulator is a mandatory regulatory requirement for their licensing. The simulator training focuses on reinforcement of expected behaviours like adherence to procedures and use of tools to prevent human errors like window alarm response sheets, pre-job briefing, three way communication, peer check, self-check and control room team building to minimize probable errors due to human factors. Performances based training, need based training and training at manufacturers place is also imparted for error free maintenance. The training programme also covers aspects related to human performance during accident conditions, as a part of validation of Emergency Operating Procedures (EOPs) during training on simulators. Human response studies are being carried out on plant simulators at KGS-1&2, RAPS-3&4 and TAPS-3&4. Human reliability studies on crew response to plant transients & accident scenarios and the recording of respective timelines for PSA studies has been regularised as a part of crew training program.

Special training courses are also arranged for all the concerned personnel on the design changes that are carried out. Training sessions relevant to human performance are also organized at different plants in coordination with international organisations like WANO. WANO programmes related to human performance are conducted, with emphasis on human performance enhancement, approach and conduct of operation in handling beyond design basis accident and improving oversight functions to enhance managerial effectiveness.

Training of the NPP staff is described in detail in chapter on Article 11: Financial and Human resources.

12.2.5 Event Analysis

An event reporting system is adopted and maintained to report events of varied significance to bring out underlying weaknesses in the system. All the events including low-level events are reported and analysed at various levels in NPCIL. The Significant Event Reports (SERs) are also reviewed in AERB. During these reviews, due consideration is given to aspects related to human performance. The lessons learnt and corrective actions taken are disseminated through an operating experience feedback system. The weaknesses and areas of concern including safety culture highlighted by the event analysis are specifically addressed during training /retraining of the operation staff. The event reporting and analysis is carried out at station as per the guidelines given in the NPCIL Head Quarter Instructions on "Event reporting to headquarters including SER for sending to WANO, review and processing" (No. 0303 R-2, Issue-1, May 2013) and on "Root cause analysis of the events" (No. 0549 R-0, Issue-1)

The low level event management programmes are implemented at NPPs as per the guidelines given in NPCIL Head Quarter Instruction no. 0534 (Revision-2, Issue-1, April 2013). As per these guidelines, the low level events, which are large in numbers, are monitored and trended for identifying latent weaknesses. The remedial measures are implemented by way of design modifications, procedural changes or through specific training modules.

In order to take care of significant events and changes having potential for impact on safety during different consenting stages of NPPs prior to operational stage (i.e. Siting, Construction and Commissioning), regulatory requirement have been introduced to submit report on the event/design change giving details as per criteria established in Event/Change Reporting Procedure (ECRP). The procedure requires conducting root cause analysis including those related to human factors. The report submitted under ECRP criteria are reviewed by AERB.

12.2.6 Maintenance

Performance monitoring of maintenance activities with respect to the human factors is carried out on a regular basis. Maintenance activities are carried out adhering to the approved procedures with appropriate stop points to ensure trouble free operation. Use of appropriate tools like training on mock-up facilities, pre-job briefing, three way communication, peer checking, self-check, Stop Think Act Review (STAR) principles are inculcated to minimize probable errors due to human factors. Post job de-briefing is done for certain types of jobs to identify the areas of improvement with respect to best practices and taking appropriate actions for enhancing human performance.[NPCIL Head Quarter Instruction no. 0548 : Conduct of Pre-Job Briefings and Post Job Debriefs] Easy maintainability, ambient conditions and access to the equipment for carrying out the maintenance are considered during design stage for better human performance.

Human performance enhancement programme is implemented at NPPs as per the guidelines given in NPCIL Head Quarter Instruction no. 0550 (Revision-0, Issue-1, July 2011).

Since 2014, five WANO programmes related to maintenance were carried out, namely on performance monitoring of equipment and system and benchmarking, maintenance fundamentals, equipment performance and condition, quality in equipment condition monitoring, preventive maintenance and break down maintenance and performance evaluation and health assessment of heat exchangers.

12.3 SELF-ASSESSMENT OF MANAGERIAL AND ORGANIZATIONAL ISSUES

Self-Assessment and Corrective Action Program are implemented in all the consenting stages of NPPs with the objective of continuous improvement in equipment condition, plant performance, work practices and safety culture. Human performance, leadership in safety, managerial and organizational aspects are adequately emphasized in the process of self-assessment. The self -assessment programme is periodically reviewed considering the operating experience and international feedback on such programmes and NPCIL headquarter instruction is suitably revised. The following peer-assessment activities are carried out at NPPs:

i. NPCIL Corporate Peer Review of NPPs

The Corporate Peer Review (CPR) of NPPs is performed once in three years by a team of experts constituted by NPCIL headquarters for a duration of 9 days. The review is carried out as per Head Quarter Instruction (HQI) no. 0535 :Self-Assessment programmes at all nuclear power plants(Revision-2,Issue-1, May 2013). Most of the team members are qualified reviewers and have attended WANO Peer Review Standard training. Some of the team members have WANO peer review experience also. This review is performed based on the document "Performance Objectives & Criteria for Corporate Peer Review, Revision-1, June 2015", which is similar to the document "WANO Peer Review Performance Objectives & Criteria". The team reviews two foundations, seven main functional areas and ten cross functional areas and submits its report to plant management and the corporate office. Team leader of the corporate review team makes a detailed presentation in the Apex Committee for Review of Operating Station Safety (ACROSS) meeting. The concerned Station Director briefs about the actions taken on the observations of the corporate review team. The status of corrective actions implemented by the station is submitted to headquarters which is further reviewed by the apex committee at headquarters.

All NPPs have developed comprehensive corrective action programme to address issues identified during the above self- assessment activities, review and analysis of low level events, near misses, events and significant events. These issues are discussed, prioritized, agency for taking corrective actions identified and due date for taking corrective actions are decided. Subsequently, these issues are entered into the corrective action programme of the station. Status of corrective action is periodically discussed in the meeting to ensure their timely completion. An action taken report is sent to HQ on the issues identified during the corporate review. Implementation status of the issues identified in corporate review is also tracked by ACROSS.

ii. NPCIL Corporate Peer Review Follow-up

Each Corporate Peer Review is followed by two CPR Follow-up Reviews in the next two years; First Follow-up Review (FFR) in the second year and Second Follow-up Review (SFR) in the third year. Thus, in a cycle of three years, there is one CPR, one FFR and one SFR as shown in the sketch below:

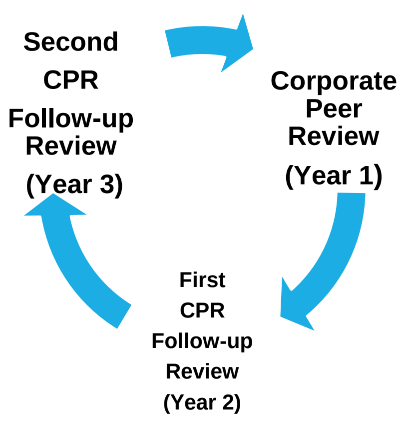


Figure - 4 : NPCIL Corporate Peer Review

FFR and SFR is done based on the document “Performance Objectives & Criteria for Corporate Peer Review, Revision-1, June 2015”. The team is constituted by Station Director of the respective NPP drawing experienced reviewers from the host plant. Some team members are taken from headquarters and other NPPs. The duration of FFR and SFR each is 6 days. After the review, the NPPs submit the Action Taken Report on the observations made during the FFR and SFR to ACROSS.

iii. Routine Self -Assessment

Routine self-assessments include work space inspections or observations, communications with workers to ensure that expectations are understood properly, identification of performance weaknesses, review, analysis and trending of important operating parameters, review of deficiency reports and low level event reports, event investigation, outage/post job critiques, system/equipment inspections and document review, practice of industrial safety & fire protection, evaluation of plant & external operating experience and periodic management review of performance.

iv. Safety Culture

The management of all NPPs prepare a list of safety culture indicators applicable to their site. The plant management is also required to carry out periodic assessment of safety culture through written questionnaire, interviews and audit activities. The assessment is used to identify good practices and areas for improvements. The aspects related to safety culture are also assessed in the Corporate Peer Review and WANO Peer Review programmes. In 2014, NPCIL hosted WANO Technical Support Mission on safety culture enhancement methodology (Refer section 10.5).

12.4 EXPERIENCE FEEDBACK ON HUMAN FACTORS AND ORGANIZATIONAL ISSUES

NPCIL Head Quarter Instruction (HQI) no. 0540 (Revision-1 , Issue-1, April 2013) provides guidance to plant management for the implementation of a structured operating experience programme (please refer sections 19.6 & 19.7). This helps in identifying further issues and areas related to human factors. To address such issues, suitable training programmes are developed and organized viz. training program on team building, root cause analysis and human performance enhancement. Refresher training programs for operation and maintenance personnel are organized periodically by training centres at respective NPPs.

12.5 REGULATORY REVIEW AND CONTROL ACTIVITIES

The multi-tier review system is a crucial element of AERB’s regulatory system. All the core regulatory processes including establishment of the regulatory requirements are carried out following the methodologies based on the ‘multi-tier review system’. The practice of founding the regulatory decisions on well-established and communicated regulatory requirements coupled with the multi-tier review, ensures that AERB’s regulatory control maintains necessary stability and consistency in its approach and implementation. AERB has formulated several procedures and checklists to perform safety review, issue licenses and carry out regulatory inspection respectively, with a view to minimize individual perceptions and varying interpretations in regulatory decision making. These procedures/ checklists provide a common ground for bringing coherence in understanding of various regulatory concepts/ approaches. The training programme of AERB further supports the consistent application of regulatory requirements by integrating various human factors and highlighting the intent of the newly formulated regulatory requirements/ criteria.

AERB is also enhancing the scope of a programme which was developed specifically for competency management within the regulatory body by identifying relevant areas for knowledge upgradation, facilitating the competence enhancement of the officials and more efficient allocation of job-assignments. Towards this, AERB arranges training programmes on issues related to current regulatory interest which span across multi-disciplinary areas and have requisite depth for regulatory application. AERB has recently conducted several training courses on very specialized technical aspects.

AERB has specified the requirement for addressing aspects relating to human performance in the design of NPPs. These topics form one of the important areas of regulatory review and assessment. AERB has established multi-tier system for regular monitoring of safety at NPPs. Events, design modifications for systems important to safety, operational performance and radiological performance are also reviewed as they have close relationship with human factors. Human factor, which is one of the safety factors of PSR is assessed periodically.

12.6 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

Human factors are given adequate consideration during all stages of NPPs. Systems for training and retraining of operating personnel including use of simulators, operational feedback including lessons learnt from the events and regulatory control are well established. Further emphasis is placed on maintaining a stress free working and living environment. Hence, India complies with the obligations of Article 12 of the Convention.

ARTICLE 13: QUALITY ASSURANCE

Each Contracting Party shall take the appropriate steps to ensure that quality assurance programmes are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of a nuclear installation.

13.1 ARRANGEMENTS AND REGULATORY REQUIREMENTS FOR QUALITY ASSURANCE

Quality Assurance Programme in India has evolved and is continually improved following National Standards and Safety Codes, which are in line with International Standards followed in the nuclear industry. The AERB Safety Code on ‘Quality Assurance in Nuclear Power Plants (NPPs)’ AERB/NPP/SC/QA (Rev. 1), 2009 provides the basic requirements for establishment, implementation and continual improvement of QA programme for all stages of the nuclear power plant viz. siting, design, construction, commissioning, operation and decommissioning. Set of safety guides issued under the Safety Code provide guidance to meet the requirements specified in the Safety Code. These safety guides are being reviewed/ revised to make them in line with IAEA Safety Requirements GS-R-3 on ‘The Management Systems for Facilities and Activities’ and Safety Guide GS-G-3.1 on ‘Application of the Management System for Facilities and Activities’.

The safety code AERB/NPP/SC/QA includes requirements on Management, Process Implementation and Measurement, Assessment, Review & Improvement. The review and assessment carried out by AERB during identified stages of consenting includes considerations of applicant’s QA Programme, as mentioned in chapter on Article-14 on ‘Assessment and Verification of Safety’.

NPCIL is the Responsible Organization (RO) for the NPPs other than Fast Breeder Reactors (FBRs) and BHAVINI is the RO for FBRs in India. NPCIL and BHAVINI have established policies, systems and programmes for quality assurance complying with the regulatory requirements. The following paragraphs provide the summary of the corporate management system as established and maintained in NPCIL. Similar practices are being followed at BHAVINI.

13.2 QUALITY ASSURANCE POLICIES AND MANAGEMENT SYSTEMS

Requirements of NPCIL quality management system are given in NPCIL document titled “Corporate Management System - Quality Management System Requirements”. The document emphasises on integrated approach for the management system for Safety, Health, Environment, Security, and Quality requirements. The document is based on AERB codes and guides, IAEA Safety Guide GS-G-3.1, ISO standards and other relevant documents.

13.2.1 Organisational Policies

The Head of the NPCIL has issued the “Statement of Policy and Authority” for the Organisation. The statement directs that a management system for Quality in the various stages of the NPPs needs to be adopted so that the safety of the NPPs, plant personnel, public and environment is assured. In the said statement sufficient authority has been delegated to the Heads of functional wings for ensuring implementation, maintenance, assessment and continual improvement of the Management System.

13.2.2 Quality Management System

The integrated Quality Management System elaborated in the “Corporate Management System Document-Quality Management System Requirements” of the NPCIL ensures implementation of the applicable AERB codes and guides. This document provides necessary directives for implementation, maintaining, assessment, measurement and continual improvement of the management system for compliance with the regulatory requirements and intents in all stages of the NPPs.

The document is being implemented during last ten years. Directorates at NPCIL HQ responsible for engineering, procurement, safety and quality assurance functions have been subjected to ISO 9001: 2008 certifications. Controls are exercised on vendors and contractors also to ensure quality.

13.2.3 Documentation

The policies, management system requirements, authority, responsibilities, procedures, work instructions, processes, activities, records and other relevant supporting information describing management of the work are duly documented and controlled. These documents reflect characteristics of the processes, activities’ sequence and their interactions. The documents are categorised into three levels as follows:

i. Level-I Document.

This is the “Corporate Management System” document of the NPCIL describing policy statement, management system, organisation structure and functional responsibilities, accountabilities, levels of authority and processes. This document further defines the interfacing and integration of the processes individuals, technology and the organization.

ii. Level-II Documents

These documents derive directives from the Corporate Management System Document and consist of Management System Manuals and all other related documents translating the corporate policies and commitments to practices and details.

iii. Level-III Documents.

These documents consist of Quality Assurance Program Manuals, Procedures, Instructions and Practices of the vendors and contractors of NPCIL to the extent they are relevant in meeting the Corporate Management System.

13.2.4 Process Management

The processes needed to achieve the mission and objectives of the NPCIL are duly identified. These processes are planned, developed, implemented, assessed and continually improved for delivering the products in accordance with the requirements of the Management Systems. The management processes are assessed for integrating the effect of technical, safety, health, environment, security, quality and financial performances, monitoring achievement of the objectives and effectiveness, and taking corrective measures where required.

Processes and activities involved in siting, design, procurement, manufacture, construction, commissioning, operations and all other supporting processes are duly documented. Requirements, sequence and interaction of processes and activities, criteria and methods needed for implementation and control, process inputs and outputs are specified and their effectiveness is ensured. Interfaces and activities of various functional directorates are planned, managed, effectively communicated to groups and individuals concerned for the specific processes, responsibilities assigned and implemented.

13.2.5 Graded Approach

It is recognised that Systems, Structures and Components (SSCs), processes and services are required to be of specified quality consistent with their importance to safety and use to which they are to be put, and accordingly classified and graded. Management System Programme has provision for such graded approach for different processes, items and services.

13.2.6 Document Control

Personnel preparing, revising, reviewing and approving the documents are specifically authorised for the work and provided with all the relevant information and resources. All relevant documents and records generated in the various phases of NPPs are duly controlled and maintained.

13.3 QUALITY ASSURANCE PROGRAMME

13.3.1 Organisation and Responsibilities

i. Organisation

The NPCIL is managed by a Board of Directors, headed by the Chairman and Managing Director (CMD). The CMD is responsible for all technical, financial and administrative functions and is assisted by the designated Technical, Financial, Administrative and other Functional Heads.

The Functional Heads are assisted by qualified personnel to perform the assigned functions, activities and applicable processes, for establishing, implementing and maintaining the Quality Management System elements in their respective areas of responsibilities.

ii. Responsibilities

"Statement of Policy and Responsibility" as defined by the NPCIL CMD, promotes a culture of conformance with the statutory and regulatory requirements, stakeholders' satisfaction, continual improvement and other requirements as elaborated in the corporate level document. The Functional and Unit Heads are responsible for managing, performing and controlling activities and processes to ensure that the products supplied and the services rendered meet the specified requirements. Functional Heads are also responsible for ensuring that the authorised personnel performing the functions are well aware of the organisational objectives, and provide requisite support to the degree necessary in achieving these objectives.

iii. Interface Arrangements

Functional interfacing and cross-functional integration of core processes i.e. Siting, Design, Procurement, Manufacture, Construction, Commissioning, Operations and de-commissioning and also the supporting processes are implemented in a coherent manner to meet the necessary agreed arrangements and responsibilities.

iv. Resource Management

Resources viz. personnel, infrastructure, work environment, information, communication, suppliers and partners, materials and finance essential for the implementation and strategy of the mission and objectives are identified, provided, maintained and improved for ensuring efficient and effective performance.

Requisite human and financial resources are provided for developing, implementing and maintaining the competencies in achieving the mission of the Utility. For this purpose suitably skilled, qualified, certified and authorised personnel are deployed and their skills are continuously upgraded by suitable training processes, thus enhancing their competence level.

13.3.2 Quality Assurance in Siting

The QA requirements for siting stage are described in Siting QA manual prepared by NPCIL. Site Selection is carried out by committee appointed by DAE and includes experts from NPCIL. For Site evaluation and Site confirmation of newly approved NPP sites, a composite group formed by CMD, NPCIL is assigned with the responsibility of various activities related to siting.

Site evaluation includes data collection, actual site investigation, detailed site evaluation and analysis of site related characteristics important to safety such as seismicity, meteorology, geology, hydrology as well as human activity in the vicinity of site, etc. Site confirmation includes confirmation of compliance with the requirements specified in regulatory codes, guides and MoEFCC notification. Siting activities are executed through reputed contractors/ Government approved agencies/ expert specialised agencies following approved procedures.

13.3.3 Quality Assurance in Design and Development

Design and development processes and activities are performed following the QA Manual for Design developed in line with the 'Corporate Management System Document'. Engineering Directorate is responsible for design, development and engineering activities undertaken by the NPCIL. Design from concept to completion is undertaken, reviewed, evaluated, analysed and validated.

13.3.4 Quality Assurance in Procurement

Procurement Directorate is responsible for procurement of SSCs for NPPs. The Directorate establishes and implements procurement management processes, consistent with the requirements stated in "Corporate Management System Document". The objective of implementing Management Systems in procurement is to ensure that procurement of SSCs is made from duly qualified and approved Suppliers, and that they meet the applicable regulatory, statutory and other stated requirements specified in the Procurement Document(s).

13.3.5 Quality Assurance in Manufacturing

Quality Management System during manufacturing assures that stated requirements for manufacturing process of SSCs are complied with. It is the responsibility of each organisation participating in the manufacture and supply of SSCs to establish and implement Quality Management System Programme so that the product meets the design requirements. The Utilities ensure maintenance of the documentation, complying with the requirements specified in the Quality Management System, throughout the lifetime of the product.

Manufacturers supplying SSCs for the NPCIL are responsible for the Quality Management processes at their premises also. The NPCIL monitors the adequacy and effectiveness of supplier's Quality Management System by the established verification processes.

All the outsourced activities (such as manufacturing/ supply of items) are governed by a formally agreed contract document. All the activities are performed according to approved QA programme, plan and procedures. The NPCIL or their authorised representative(s), have access to relevant areas where work involving the concerned Contract/ Purchase Order for carrying out quality surveillance. This includes access necessary for inspections of contractors' facilities/ activities to verify implementation of all aspects of the Quality Management System / Quality Assurance Programme, products and to their supplier's premises. Findings of these inspections and required corrective actions are documented.

13.3.6 Quality Assurance during Construction

Quality Management Systems are elaborated in the respective project level document derived from the corporate level document for construction of the NPP, to ensure that civil works, erection, installation and associated testing of Reactor, Piping, Mechanical, Electrical and Control and Instrumentation systems, and SSCs are carried out safely and meeting the specified requirements.

The Head of the NPP construction site is responsible for establishing and implementing the Management systems during project construction. He is duly supported by independent groups headed by competent personnel for the civil, mechanical, reactor, electrical, piping, control and instrumentation works and auxiliary systems. Independent Field Engineering and Quality Assurance Groups are also set up for overseeing design and quality aspects respectively during the construction phase.

13.3.7 Quality Assurance in Commissioning

Commissioning activities commence after completion of respective construction activities. The transfer of responsibility from construction to commissioning is documented through Construction Completion Certificate (CCC) and System Transfer Documents (STDs). All commissioning work is systematically planned, accomplished, assessed by the competent personnel and documented. Quality Management system implemented during commissioning assures commissioning is performed as per the approved procedures. The verification confirms that the acceptance criteria specified in the applicable documents are met and deficiencies, if any, are corrected. For this purpose inspection and conformity checking is done to verify compliance. All specific or general deficiencies are identified, documented, investigated and rectified. All corrective and preventive actions, as required, are implemented after due analysis of non-conformances / potential non-conformances.

13.3.8 Quality Assurance during Operation

Quality Management Systems implemented during operation assure that the NPPs are operated safely, in accordance with the design intent and within the specified operational limits and conditions as stipulated in the technical specifications. Head of the Directorate of Operations at the corporate level is responsible for the operating plants. Plant Management at each NPP is headed by a Station Director (SD) reporting to the Head of Operations at Corporate level. SD is responsible for establishing, implementing and effectiveness of the Management system Programme for safe operation of the station. He has the overall responsibility for safe operation of the plant, in implementing all relevant requirements, instructions and procedures laid down by the NPCIL, AERB and Statutory Bodies. Responsibilities and authorities of plant management and functional positions have been stated in the Station Policies for each station. The QA group at NPP is responsible for inspection, testing, quality assurance, surveillance, verification, auditing, ISI, monitoring and assessing the effectiveness of QMS and its improvement, for all activities of station operation and following the applicable QMS Documents.

13.4 IMPLEMENTING AND ASSESSING QUALITY ASSURANCE PROGRAMMES

The Management System of the NPCIL has the requisite processes and systems to monitor and measure levels of performance achieved in effective implementation of the QMS (QA programme). The levels of performance are based on use of performance indicators, measuring with reference to the objectives set by the management and delivered product. Measures for continual improvement are initiated in the management system accordingly.

The Senior Management identifies, prevents and corrects management problems that hinder achievement of the NPCIL objectives. By due assessment process at all levels effective implementation of the organization’s QA programme is realised. Self-assessment at all levels is considered to be an effective tool to achieve these objectives. All the Managers and Task Performers periodically perform self-evaluation in their areas of work to compare current performance to management expectations in respect of worldwide industry standards of excellence (bench marking), meeting stakeholder requirements and expectations, regulatory and statutory requirements, and to identify areas based on any incidences that takes place worldwide or any other inputs received needing improvement.

13.5 REVIEWS AND AUDIT PROGRAMME

A system of planned and documented audits/reviews within the NPCIL organisation like functional directorates, units under construction and operating stations is established and carried out to verify compliance, determine effectiveness of implementation of all aspects of the Management System and for continual improvement of the programme. Similar audits are also carried out in the organisations of suppliers and sub-suppliers.

13.6 REGULATORY REVIEW AND CONTROL ACTIVITIES

The AERB’s integrated management system identifies safety as a priority and provides guidance for its promotion and continual improvement as referred in 8.1.2.8. The review and assessment by AERB includes consideration of the applicant’s organisation, management, procedures and safety culture, which have a bearing on the safety of the plant. The applicant should demonstrate that effective management system is in place that gives the highest priority to nuclear safety and security matters. Specific aspects as mentioned in the AERB Safety guide "Consenting Process for NPPs" (AERB/SG/G-1) subject to review and assessment, include:

i. Whether the applicant's safety policy emanates from senior management and shows commitment at a high level to safety requirements and the means to achieve them.

ii. Whether the applicant's organisation is such that it can implement the commitments made in the safety policy, through existence of adequate procedures, practices and organisational structure.

iii. Whether the applicant has procedures to ensure that there is adequate planning of work, with suitable performance standards, so that staff and managers know what is required of them to meet the aims and objectives of safety policy.

iv. Whether the applicant has a system in place to periodically audit its safety performance.

v. Whether the applicant has procedures in place to review periodically all the evidence on its safety performance in order to determine whether it is adequately meeting its aims and objectives and to consider where improvements may be necessary.

vi. Whether the applicant has culture, commitment, organisation, systems and procedures, to meet the nuclear security requirements.

The review and assessment by AERB covers all aspects of the applicant's managerial and organisational procedures and systems which have a bearing on nuclear safety (such as operational feedback, compliance with specifications, operating limits and conditions, planning and monitoring of maintenance, inspection and testing, documentation, control of contractors, and implementation of additional features based on incidences worldwide).

AERB review also includes assessment of effectiveness of vendor inspections carried out by NPCIL or its authorised representative(s).

13.7 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

The comprehensive Quality Management System (QMS) in the regulatory body and the utilities has been developed in accordance with the national and international standards which is maintained and further improved through programme of monitoring and assessment of its effectiveness. The regulatory review and assessment activities ensure that there is an effective safety management system in place that gives nuclear safety matters the highest priority. Therefore, India complies with the obligations of the Article 13 of the Convention.

ARTICLE 14: ASSESSMENT AND VERIFICATION OF SAFETY

Each Contracting Party shall take the appropriate steps to ensure that:

i. **comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information, and reviewed under the authority of the regulatory body;**

ii. **verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions.**

14.0 GENERAL

The assessment and verification of safety is an integral part of the nuclear power programme. AERB Safety Code, AERB/SC/G: 2000, on "Regulation of Nuclear and Radiation Facilities" spells out in detail the obligations of the licensee and the responsibilities of the AERB.

The utilities perform their own safety assessment and verification functions to ensure the likelihood of occurrence of an accident with serious radiological consequences is extremely low and that the radiological consequences of such an accident would be mitigated to the fullest extent practicable in line with regulatory requirements. Even in the accident with core melt, only limited countermeasures in area and time are needed in the public domain and sufficient time is available to implement these measures. They carry out these functions during design, manufacturing, construction, commissioning and operation. Separate corporate level safety committees for the projects (plants under construction and design) and for operating plants are constituted for safety review and assessment. All the information generated during the entire design, construction and commissioning phases is documented and handed over to the Plant Management before the commencement of reactor operation.

AERB establishes its programmes for assessment and verification of safety during all the consenting stages viz. Siting, Construction, Commissioning and Operation. These programmes are based on routine and special reports from the licensee and regulatory inspections carried out by AERB. The objective of assessment and verification programmes by AERB is to ensure that the utility's own programmes are adequate and satisfactorily implemented. A multi-tier system of safety committees is followed for carrying out regulatory review and assessment during all the consenting stages.

14.1 ASSESSMENT OF SAFETY

14.1.1 Regulatory Process for Safety Assessments

14.1.1.1 Consenting Process

AERB Safety Guide AERB/NPP&RR/SG/G-1 on "Consenting Process for Nuclear Power Plants and Research Reactors" explains the entire consenting process for nuclear installations followed in India. The safety guide defines the regulatory consenting process at all the major stages of a nuclear installation. It gives in detail the information required to be included in the submissions to AERB, document, schedule for submissions, and areas of review and assessment for issuing the regulatory consent. Assurance of safety during various stages of NPP is derived through this process. Under the process, consent is issued for siting, construction and commissioning. Regulatory clearances are issued for intermediate stages during construction and commissioning. License is issued for operation of NPPs. The consents and licenses are issued by AERB on the basis of its safety review and assessment of the submissions made by utility.

License for operation of NPP is issued for a period up to five years at a time. The renewal of license for operation is issued by AERB based on safety reviews as specified. These are (a) safety review of application submitted in the prescribed format, three months prior to completion of five years of operation and (b) Review of Report on Periodic Safety Review (PSR) every ten years of operation. Thus in a ten year cycle, NPPs seek two license renewals for operation, first after five years and the second after ten year based on PSR. In case of NPP of new design, the first PSR is carried out after five years of operation and the subsequent PSRs of these NPPs are carried out at 10 year intervals.

14.1.1.2Safety Review Mechanisms

i. Utility

In accordance with the regulatory requirements of an independent internal review of design and operational aspects of NPPs, utilities have set up internal review mechanisms. The documents related to design of Nuclear Power Plants are submitted to regulatory body after in-house reviews by the utility. Where a first-of-its-kind design or feature is introduced or there is a departure from an established engineering practice, utility demonstrates its adequacy by appropriate supporting research programmes, analytical and experimental studies or by examining operational experience from other relevant applications. The new design or features are adequately tested before being brought into service and monitored during service, to verify that their behaviours are as expected. In case of repeat design, any change in design involving a new concept (e.g. software based system compared to hardwired system) goes through an independent review. All the issues raised by the independent reviewer are resolved. Subsequently, Safety Review Committee (Projects and Design) of the utility organisation independently reviews the documents and after satisfactory resolution of the identified issues, documents are submitted to AERB. The observations / issues coming out of review in AERB are resolved, documents are revised and re-submitted to AERB for formal clearance. The document finally cleared by AERB forms the basis for the detailed design and further engineering.

Before start of commissioning activities, utility prepares a comprehensive programme for the commissioning of plant components and submits the same for review and acceptance by AERB. During commissioning of plant, utility assesses the performance of various systems of the plant to verify that it meets the design objectives.

Elaborate organisational structure (please refer chapter on Article 19) is established at each plant for reviewing safety aspects during operation. Station Operation Review Committee (SORC) headed by Station Director is established at each NPP. SORC reviews station operations on routine basis to detect potential safety issues. At the corporate level, Safety Review Committee (SRC) for operating NPPs with representation from design, safety, operation and quality assurance groups at utility headquarters reviews all safety related proposals, including engineering changes, which require review and concurrence by AERB. The recommendations made by SRC are incorporated before the proposal is forwarded to AERB.

ii. Regulatory Body

AERB adopts a multi-tier review process for safety review and assessment of NPP during all the consenting stages.

The in-house review of various design documents submitted by the utility during project stage, regulatory surveillance of the construction activities at project site, review of commissioning activities and enforcement of regulatory recommendations are done by Nuclear Project Safety Division (NPSD) of AERB with support from other divisions. AERB conducts independent verification and research activities in several subject areas such as safety analysis, thermal hydraulics, containment hydrogen distribution and mitigation, severe accident studies and assessments and computer code development. AERB uses internationally validated and accepted system codes, lumped parameter codes, structural analysis codes along with AERB in-house developed computer codes to carry out these independent activities. AERB also conducts research and development activities relating to structural integrity, seismic safety and flood hazard assessments. These activities are intended to support AERB decision making, regulatory document development and the development of state-of-the-art approaches and expertise capability.

Operating Plants Safety Division (OPSD) of AERB carries out regulatory surveillance of operating NPPs. This involves review of radiological safety aspects of NPPs, radioactive effluents releases from NPPs, proposals for modification in design of safety system, technical specifications for operation of NPPs, emergency preparedness plans, periodic safety reviews related to license renewals, events & significant events, etc. OPSD is supported by other divisions of AERB in some of these activities.

During siting, construction and commissioning, the first level of review and assessment is performed by Site Evaluation Committee (SEC), Project Design Safety Committee (PDSC)/Specialist Groups and/or Civil Engineering Safety Committee (CESC), as appropriate. These Committees are comprised of experts in various aspects of NPP safety. The next level of review is conducted through an Advisory Committee on Project Safety Review (ACPSR). This committee is a high-level committee with members drawn from AERB, Technical Support Organisation (TSO), other national laboratories having specialised expertise and academic institutions. It also has representation from other governmental organisations like Ministry of Environment, Forests and Climate Change (MoEFCC), Central Electricity Authority and Central Boilers Board. This advisory committee reviews the application for consent together with the recommendations of the first level committees on the related consent and gives its recommendations to AERB. After considering the recommendations of first level committee and ACPSR, the Board of AERB decides on the consent. Annex 14-1 to 14-4 illustrate the review process followed during siting, construction, commissioning and operation stages.

During operation, AERB follows a multi-tier approach involving review at three levels viz. Unit Safety Committee (USC), Safety Review Committee for Operating Plants (SARCOP) and the Board of AERB. ‘Unit Safety Committees’ consist of representatives from AERB, experts in various aspects of nuclear technology drawn from Technical Support Organisation and utility headquarters. SARCOP is the apex body to decide on the matters of nuclear safety and has members from AERB staff, experts drawn from TSO, retired experts and one member from the headquarters of the utility. The third-tier is the Board of AERB, which based on the recommendations of SARCOP, considers major safety issues pertaining to NPPs. Chairman, SARCOP is an ex-officio member of the Board of AERB. Annex 14-5 gives the aspects of safety review during operation of NPP. The system of safety committees function on the principle of "management by exception" following a graded approach. Safety issues of greater significance are further reviewed in higher-level safety committees for resolution. The recommendations of these committees are accepted by AERB after ensuring that they are in line with the safety goals, principles and requirements laid down by AERB.

14.1.2 Safety Reviews during Consenting Process

14.1.2.1 Safety Review for Siting

First order assessment of the sites is carried by Standing Site Selection Committee (SSSC), constituted by the Government of India. It evaluates the suitability of the various sites proposed by concerned state governments taking into account different site related factors as detailed in Chapter on Article-17.

The first regulatory stage of consenting i.e. Siting, involves the review of the various site related safety aspects considering the conceptual design and issuance of siting consent for locating the NPP. This requires submission of a Site Evaluation Report which includes the salient features of the proposed site, basic design information of the proposed NPP, site characteristics affecting safety and impact of the proposed plant on surrounding population and environment. The Site Evaluation Report should contain information as per requirements specified in the AERB Code No. AERB/NF/SC/S (Rev.1, July 2014) on ‘Site Evaluation of Nuclear Facilities’ and various other relevant AERB Siting guides. This code considers the lessons learnt from Fukushima, including revised dose criteria for design of NPPs in normal operation as well as accident conditions giving due considerations for exceedance of design basis, evolution of hazard with time, multi-unit/multi-facility sites, periodic re-evaluation of hazards during the plant lifetime and requirements regarding ultimate heat sink.

The objective of the review for this stage is to ensure that the proposed site is suitable for the construction and operation of an NPP in a safe manner and to determine the potential consequences of interaction between the plant and the site. The areas of review and assessment are as per AERB safety guide AERB/NPP&RR/SG/G-1: 2007 on 'Consenting Process for Nuclear Power Plants and Research Reactors' and are given in Article 17. The regulatory process for reviews related to siting consent is given in Annex 14-1.

14.1.2.2 Safety Review for Construction

The second stage of consenting i.e. Construction, involves review of the design safety aspects and issuance of construction consent. Main aspects of interest for regulatory review and assessment of the adequacy of the design basis for a nuclear power plant are brought out in AERB Safety Codes such as AERB/SC/S, AERB/SC/D, AERB/NPP/SC/QA and Safety Guides published thereunder.

The issuance of construction consent requires on the part of the applicant, submission of Preliminary Safety Analysis Report (PSAR) in the prescribed format, the applicant's site construction Quality Assurance manual, construction schedule and construction methodology document for the proposed NPP to AERB for review and acceptance. AERB also reviews the documents related to industrial safety such as Construction Safety Management Manual, Job Hazard Analysis Report etc. and monitors their compliance to the requirements of Atomic Energy (Factories) Rules, 1996.

Depending on the request from the applicant, AERB may issue the consent for construction as a one-time authorisation for total construction activities or as clearance in three sub stages viz. clearance for excavation, clearance for first pour of concrete and clearance for erection of major equipment. If consent for construction is issued in these clearance stages, PSAR reviews are organized according to the specified requirement for these stages.

During the reviews related to this consenting stage, the design of plant is reviewed and assessed to reach a conclusion as to whether it can be built to operate safely. This review and assessment includes verification of the compatibility of the design with the site. The quality assurance organisation and program of the utility is also reviewed. Review and assessment, carried out by AERB, is focused to ensure that in the design of a nuclear installation, all actual and potential sources of radiation exposure are identified and properly considered, and provision are made to ensure that sources are kept under strict technical and administrative control.

During review and assessment, it is ensured that, the following fundamental safety functions will be performed in all operational states, during and following design basis accidents and, to the extent practicable, including under design extension conditions also:

(i) control of the reactivity;

(ii) adequate heat removal from the core; and

(iii) confinement of radioactive materials and control of operational discharges within prescribed limit, as well as to limit accidental releases within acceptable limits.

The key aspects of interest of regulatory body, are:

- Application of Defence in Depth Requirements and Principal Technical Requirements including Safety Functions, Accident Prevention and Plant Safety Characteristics, Radiation Protection.
- Plant Design Requirements including Safety Classification, Categories of Plant States, Postulated Initiating Events, Design Limits, Internal Events, External Events, Site-related Characteristics, Combination of Events, Design Criteria, Operational States, Design Basis Accidents, Design Extension Conditions.
- Design for Reliability of Structures, Systems and Components which includes , Common Cause Failures, Single Failure Criterion, Fail-safe Design, Safety Support Systems, System Storage Capacities, Equipment Outages

- Provision for In-Service Testing, Maintenance, Repair, Inspection and Monitoring, Equipment Qualification, Aspects related to Ageing and Human Factors
- Sharing of Structures, Systems and Components in Multi-reactor, Fuel and Radioactive Waste Transport and Packaging, Escape Routes and Means of Communication, Control of Access and,
- Plant System Design Requirements for all systems important to safety.

The primary objective of NPP designs is to prevent accidents and to mitigate the consequences should an accident occur, by application of principles of defence in depth.

AERB initiated development of a Safety Code on Design of Light Water Reactor based Nuclear Power Plants (AERB/NPP-LWR/SC/D) soon after the 2nd Extraordinary Meeting of CNS, addressing the lessons learnt from Fukushima accident. The code was issued in January 2015. As per the requirements specified in this code, provision shall be made in the design for automatic safety actions for the necessary actuation of safety systems or additional safety systems/features, to prevent progression of accident to more severe plant conditions. The safety code also requires provision of complementary safety features for mitigating the consequences of severe accidents, should they occur. Further, the design of NPPs shall be such that design extension conditions that could lead to large or early releases of radioactivity are practically eliminated. For design extension conditions that cannot be practically eliminated, only protective measures that are limited in terms of area and time shall be necessary for protection of the public, and sufficient time shall be made available to implement these measures. The design and regulatory assessment of new NPPs will be done to meet these requirements.

The generic requirements and design principles specified in the LWR design code are considered during design & safety review of the PHWR based NPPs also. The Safety Code “Design of Pressurised Heavy Water Reactor based Nuclear Power Plants” (AERB/NPP-PHWR/SC/D (issued in 2009) is being revised to include these requirements.

These design objectives are consistent with the objectives of Vienna Declaration on Nuclear Safety.

14.1.2.3 Safety Review for Commissioning

Commissioning activities in NPP are initiated in parallel during the later period of construction. Various equipment and systems are individually commissioned as and when the prerequisites for their commissioning are met. The first regulatory clearance within the commissioning consent is required when the applicant desires to initiate the integrated commissioning activity e.g. hot conditioning (integral testing and passivation of primary heat transport system) in the case of PHWR based NPPs. Following this, there are a number of intermediate commissioning stages at which also regulatory clearances are required. The consent for commissioning is given in several interim stages as deemed necessary by AERB. These interim stages act as checkpoints where the results of previous activities and prerequisites for further activities are reviewed prior to issuing clearance for the subsequent stage. The guidelines for safety review and assessment for commissioning of NPPs are given in safety guide AERB/NPP&RR/SG/G-1. Some of these interim stages e.g. containment integrity test, fuel loading, approach to first criticality, low power physics experiments, etc. are witnessed by the representatives of AERB, if required. AERB safety guide AERB/SG/O-4 and AERB/NPP-PWR/SG/O-4 C provides guidance for the commissioning procedures for PHWR and PWR based reactors respectively.

For commissioning consent, AERB reviews the final or ‘as built design’ of the nuclear power plant as a whole. AERB satisfies itself that (a) the plant has been built in accordance with the accepted design and meets all the regulatory requirements, (b) the required level of quality has been achieved and (c) the safety review and assessment of all relevant systems including the required tests have been satisfactorily completed.

The review and assessment by AERB also covers all aspects of the applicant's managerial and organizational procedures and systems, including the availability of required trained and qualified personnel for operation, which have a bearing on safety.

AERB requires that at this stage, the utility should establish following:

i. Surveillance, maintenance and in-service inspection programs.

ii. Performance review and operational experience feedback programmes

iii. Programmes for Ageing Management

iv. Radiation protection programme

v. Emergency Preparedness and Response plans

vi. Training program for operating personnel

vii. Records and reporting system

viii. Quality assurance programme for all commissioning, operation and maintenance activities

ix. Nuclear Security aspects affecting safety

14.1.2.4 Safety Review for License for Operation

The License for regular operations is issued after review of NPP performance at rated power for a period which is typically 100 days. During this period, specified tests are conducted to confirm behaviour of the plant as per design. To obtain the license for regular power operation, the applicant has to submit a Final Safety Analysis Report (FSAR) reflecting the 'as built' design of the NPP, Technical Specifications for Operation incorporating the feedback from commissioning process and detailed performance reports, in support of the application.

Before issuing license for operation, AERB reviews the results of commissioning tests and performance data at various power levels for their consistency with design information and with the prescribed operational limits and conditions. Inconsistencies, if any, have to be resolved to the satisfaction of AERB. After completion of the reviews, AERB issues license for regular operation of NPP for a period up to five years.

14.1.2.5 Safety Review during Operation

Operation of the nuclear installations in India is carried out in conformance with the AERB safety code on 'Nuclear Power Plant Operation, AERB/NPP/SC/O (Rev. 1): 2008 and the safety guides made thereunder (AERB/SG/O-1 to O-15). During regular operation, reviews are carried out to ensure that the operation of the plant is being carried out in accordance with the approved Technical Specifications, FSAR, AERB codes & guides and the licensing conditions. These reviews include:

i. Routine safety reviews and assessments

The safety supervision during operation mainly includes continual monitoring and assessment of operational and safety performance, radiological safety, maintenance and in-service inspection activities and the results thereof and findings of regulatory inspections.

ii. Periodic safety assessments

License for operation of NPP is issued by AERB for a period of up to five years at a time. Renewal of the licenses is based on a comprehensive safety review once in 5 years and conduct of PSR, once in 10 years. However, first PSR of new design plants is carried out after five years of operation. Linking of the periodic comprehensive safety reviews and PSRs with the renewal of operating licenses helps AERB in ensuring that the identified safety enhancements are implemented timely.

The utility conducts the safety assessment of the plant in accordance with the guidelines given in AERB safety guide 'Renewal of Authorisation for Operation of Nuclear Power Plants' (AERB/SG/O-

12, August 2000) (under revision) and submits application in a prescribed format for renewal of license. The safety assessment includes operational and radiological safety performance, operational experience feedback, physical status of plant including major modifications and public concern in operational safety. The report is submitted to AERB three months prior to the expiry of the operating license. AERB conducts a detailed review of the same and issues the license after being satisfied that the plant could be operated in a safe manner at the power levels authorised for the plant within the operational limits and conditions specified in "Technical Specifications for Operation" and that the continued operation of NPP till the next renewal would not pose undue risk to the plant, plant personnel, public and the environment. During the last three years, safety assessment for license renewal were conducted for RAPS-1&2 and RAPS-5&6.

Additionally, utility conducts a Periodic Safety Review (PSR) as per the AERB Safety Guide AERB/SG/O-12 Comprehensive safety assessments performed during PSR take into account improvements in safety standards and operating practices, cumulative effects of plant ageing, modifications, feedback of operating experience, deterministic & probabilistic safety analysis and development in science and technology. As a part of this PSR, the hazard assessments are revisited with the latest available information. Through this process of PSR, the strengths and shortcomings of the NPP against the requirements of current standards are identified. The report on PSR is submitted to AERB six months prior to the expiry of license. During the last three years, PSRs were conducted for TAPS-1&2, MAPS-1&2 and KAPS-1&2.

The PSR is subjected to regulatory review in the multi-tier review process. A dedicated group having multi-disciplinary skills, vast experience of regulatory inspections and safety reviews & assessment is constituted in AERB for review of PSR submitted by licensees. Sub-groups with necessary expertise are constituted for completing the review of the identified safety factors of PSR in a time bound manner. The support of experts from TSO is also taken for review of some specific issues such as ageing management of important SSCs, equipment qualification and safety analysis, as necessary. The experience gained from the review of PSR of one NPP is effectively utilised in reviewing the PSR of the subsequent NPPs. This facilitated efficient and effective review of the PSRs in the past three years.

As a part of periodic safety reviews, the safety assessments of. TAPS-1&2, RAPS-1&2, MAPS and KAPS were revisited with respect to flood hazards, owing to their revised reference levels for external flooding. The older plants viz. TAPS-1&2, RAPS-1&2 and MAPS which were earlier subjected to seismic reevaluation (during 2002-2006) as per the then methodology of IAEA Safety Reports Series no. 28 on 'Seismic Evaluation of Existing Nuclear Power Plants', were further subjected to seismic reevaluation and strengthening based on the current approach. This re-evaluation also addressed the observations of the safety review of the Indian NPPs done following the Fukushima accident.

All the Indian NPPs which became operational prior to 2006 have undergone at least one PSR since the initiation of the PSR process in the early 2000s.

The safety upgrades identified as part of PSR are followed up for timely implementation by AERB as renewal of operating licenses for the NPPs are linked to the PSRs.

The established system of comprehensive periodic safety assessment and license renewals of Indian NPPs to assess the safety of the plant with respect to the original design basis, current safety requirements / practices& operating experience and implementation of the identified upgrades, as is being practiced, address the principle of Vienna Declaration on Nuclear Safety.

14.1.3 Regulatory Review and Control Activities

14.1.3.1 NPPs under construction and commissioning

AERB undertakes regulatory review and control activities during various consenting stages like Siting, Construction, Commissioning and Operation. During construction and commissioning stages, there are a number of sub-stages at which regulatory clearances are required. These stages act as checkpoints where the results of previous activities and pre-requisites for further activities are reviewed till the plant is brought to operational state.

Responsibility of QA & QC during manufacturing, fabrication, construction and commissioning rests with the Utility. Regulatory process calls for setting up mechanisms within the utility to carry out internal audits by specifically constituted groups of various activities/jobs executed by the constructors, vendors, utility etc. Regulatory Inspection teams check these audit reports in addition to physical verification and scrutiny of various documents/ records related to QA & QC, preservation and storage, industrial and fire safety aspects, adherence to regulatory stipulations etc. Observations and recommendations of regulatory inspection are required to be complied with and responded to by the utility. The utility is asked to check and apply these observations / recommendations suitably on similar types of jobs/ activities. AERB has developed a system for reporting the significant events/ change reporting procedure for nuclear projects to report conditions during design, manufacturing, construction and commissioning that may affect the characteristics of safety and safety related Structures, Systems and Components (SSCs).

Regular safety review and assessment for NPPs during construction and commissioning is conducted by the designated AERB staff that also has the responsibility of organizing and follow up of the regulatory inspections. In addition to normal regulatory inspections, AERB also identifies a list of important activities during construction and commissioning for deputing its experts in the respective areas to witness these activities as observers. As KK NPP-1&2 is the first PWR based NPP in India, AERB observers were deputed to provide regulatory surveillance during the commissioning activities of this plant on continuous basis, in addition to routine regulatory inspections and deputation of the experts for witnessing important activities. The reports on these activities including the remarks by AERB observers are taken into account for giving clearance for further stage during construction/commissioning. AERB staff participates in all the review and assessment functions, regulatory inspection and witnessing of the important activities.

With this arrangement of regulatory supervision, all the important activities having bearing on safety get adequate regulatory coverage.

14.1.3.2 NPPs in Operation

AERB exercises regulatory control over the nuclear power plants following a system of safety monitoring, inspection and enforcement and periodic assessment. From the early phase of the nuclear power programme, India has been following a proactive approach towards safety enhancements in the NPPs. The regulatory processes, which evolved over a period of time have adopted many of the best practices with respect to safety and regulation. Indian regulatory system always placed strong emphasis on learning from experience and using it to enhance safety. This character has helped the nuclear industry, the regulator and the R&D community to evolve with the times to achieve and maintain high level of safety in accordance with the societal expectations.

In line with this, the regulatory system incorporates ‘special safety reviews’, undertaken following major events, wherein the implications of such experience and lessons are reviewed for identifying and implementing safety enhancements. Indian NPPs have undergone many such reviews, examples of which include the Three Mile Island accident of 1979, the Chernobyl accident of 1986, the fire incident at Narora Atomic Power Station (NAPS) in 1993, Flood incident at the Kakrapar Atomic Power Station (KAPS) in 1994, the Tsunami at the Madras Atomic Power Station (MAPS) in 2004, the Fukushima accident in 2011 and the incident of pressure tube leak in KAPS-1&2 on July 1, 2015 and March 11, 2016. All these reviews have resulted in enhancements in the safety features and regulatory requirements

The operational NPPs undergo routine and special safety reviews as described below:

i. Reports to AERB

AERB obtains various reports from the NPPs such as monthly and annual performance reports, report on long outages for carrying out surveillance, in-service inspection & major maintenance. In addition, AERB reviews events which are reported as per the event reporting system (refer section 19.6) and assesses INES rating of these events.

ii. Design modification in safety & safety related systems

Any design modification in the safety and safety related systems of the plant has to pass an in-depth regulatory review and approval. For such modifications, the utility submits the plant modification proposal in the prescribed format, which must be accompanied by a safety assessment report both by the station staff and designers at the corporate level. The clearance for implementation of the proposed modifications in safety & safety related systems is accorded by AERB after satisfactory reviews in USC and SARCOP. AERB may seek the opinion of experts or refer the matter to any of the national laboratories or academic institutions for independent analysis for verification of the claims of the utility.

iii. Regulatory inspections

AERB conducts regulatory inspections of NPPs to check compliance to regulatory requirements. The report of the RI with observations and recommended actions is prepared and forwarded to the licensee for taking corrective actions. Licensee is required to submit an action taken report on the deficiencies brought out during the inspection within a specified time frame. These submissions are reviewed in AERB for disposition and need for enforcement action if any. The team leader of the regulatory inspection team has been authorized to take on-the-spot decisions in cases of extreme non-compliance.

iv. Radiological Safety Status

AERB gets periodic reports on the radiological protection programme from the HPU in the plant and the environment monitoring from the ESL at each NPP site. AERB committees review these reports along with the response of NPP management on the same.

v. Management of radioactive waste

The performance of radioactive waste management system established at NPPs is reviewed to ensure that appropriate methods and management practices continue to be in place and the generation of radioactive waste is kept to a minimum as practicable in terms of activity and volume. AERB issues the authorisation for release / transfer of radioactive waste from all the NPPs under the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987. These authorisations are valid for three years and renewed after review of the basis of performance of NPPs.

vi. Emergency Preparedness

The NPPs carry out periodic exercises for plant, site and off site emergency according to the prescribed frequency. The reports of these exercises are reviewed in AERB. Various state and central agencies participate in the offsite emergency exercises. AERB also deputes its representatives as observers to oversee the conduct of the off-site exercise. Emergency Preparedness and Response plans are periodically updated based on the changes in organisation and infrastructure. A comprehensive review of the emergency preparedness and response plans, infrastructure required and roles & responsibilities of the agencies involved in emergency response was carried out after the accident at Fukushima NPPs. The details are given in Article 16.

vii. Training and qualification of operating staff

The Technical Specification identifies the qualification levels for operating staff and the management. The curricula of different licensed positions are prepared by the utility and vetted by the AERB. The operating staff undergo system of classroom training, on the job training, checklist, walk through and simulator training and are interviewed by the AERB Committee on Qualification of Operating Personnel. Similarly, AERB evaluates the personnel in the management positions through an AERB Committee on Licensing of the Station Management Personnel for the initial license and renewal of License. The license is generally valid for three years after which the candidate undergoes a retraining exercise and again appears before the appropriate AERB Committees. The details of the entire training programme are given in chapter on Article 11.

14.2 VERIFICATION OF SAFETY

14.2.1 Regulatory Requirements for Verification of Safety by the Licensee

AERB Safety Codes on design of NPPs, AERB/NPP-PHWR/SC/D (Rev.1) 2009 for PHWRs and AERB/NPP-LWR/SC/D, 2015 for LWRs, require that a comprehensive safety assessment shall be carried out to confirm that the design, as used for construction and as built, meets the safety requirements set out at the beginning of the design process and the utility shall ensure that an independent verification of design and the safety assessment is performed by an independent group, separate from that carrying out the design, before it is submitted to the AERB.

"Safety Code on nuclear power plant operation", AERB/NPP/SC/O:2009 (Rev.1) establishes requirements related to operation of NPPs and several safety guides issued under this Code, describe and make available methods to implement specific requirements of the Code. The code requires establishment of management programmes related to operation review and audit with the aim of ensuring that an appropriate safety consciousness and safety culture prevails. In accordance with the requirements, an elaborate verification programme is established at NPPs and the adequacy of the programme is periodically monitored. Audits are conducted by plant management and also the utility headquarters to verify that the safety verification programmes are being followed at the plant.

14.2.2 Programmes for Continued Verification of Safety

The important elements of effective management for safe operation of a NPP are given in AERB Guide no. AERB/SG-9 on Management of Nuclear Power Plants. As per the regulatory requirements, the plant management is required to establish the following programmes before a license for operation is issued:

i. Surveillance Programme - The surveillance programme for safety systems and systems important to safety are included as part of the Technical Specifications for Operation. Through this, it is verified and ensured that the safety of the plant does not depend upon untested or unmonitored components, systems or structures. The programme includes tests like functional tests, calibration checks for Protection Systems, Emergency Core Cooling System, Containment Systems, Emergency Power Systems and various other important Systems, Structures and Components (SSC) important to safety. The guidelines for surveillance programs are given in AERB Safety Guide AERB/SG/O-8 on 'Surveillance of Items Important to Safety in Nuclear Power Plants'.

ii. In-service Inspection Programme - As per this programme, plant components and systems are inspected for possible deterioration in safety margins and their acceptability for continued operation of the plant and to take corrective measures as necessary. SSCs important to safety of the plant are identified in the In-service Inspection manual, which gives the requirements with respect to (a) areas and scope of inspection (b) frequency of inspection (c) method of inspection and (d) the acceptance criteria. The guidelines for in-service programme are given in AERB Safety Guide AERB/NPP/SG/O-2 on 'In-service Inspection of Nuclear Power Plants'.

iii. Maintenance Programme - The maintenance programme is put in place to ensure that (i) safety status of the plant is not adversely affected due to ageing, deterioration, degradation or defects of plant structures, systems or components since commencement of operation and (ii) their functional reliability is maintained in accordance with the design assumptions and intent over the operational life span of the plant. The NPP prepares a preventive maintenance schedule for systems, structures and components. In addition, system for trend monitoring of the important equipment is used for predictive maintenance. The preventive maintenance includes surveillance and verification, periodic preventive maintenance and predictive maintenance. The guidelines for maintenance programs are given in AERB Safety Guide AERB/SG/O-7 on Maintenance of Nuclear Power Plants.

iv. Establishment of programme related to life management - This programme is used to obtain information on behaviour of the SSCs, as identified for ageing management purpose, under reactor environment and to undertake necessary studies/experiments with respect to their residual life assessment. The guidelines for life management are given in AERB Safety Guide AERB/NPP/SG/O-14 on Life Management of Nuclear Power Plants.

v. Performance Review Programme - The basic purpose of this programme is to identify and rectify gradual degradation, chronic deficiencies, potential problem areas or causes. This includes review of safety-related events and failures of SSC of the plant, determination of their root causes, trends, pattern and evaluation of their safety significance, lessons learnt and corrective measures taken.

vi. Programme to update Probabilistic Safety Assessment - The programme for collection of plant specific failure data at NPPs is established for evaluation of reliability of safety systems. These data are judiciously used to update the results of PSA studies. The proposals for design modifications or revision in technical specifications are supported by the results of PSA studies, whenever required.

Arrangements for internal review by the utility both during projects and operation are described in section 14.1.1.2.

14.2.3 Regulatory review and control

AERB exercises regulatory control over the nuclear power plants following a system of safety supervision, inspection and enforcement and periodic assessment for renewal of License.

i. Continuous Safety Supervision

The safety supervision during operation includes continual monitoring and assessment of operational and safety performance, radiological safety, maintenance and in-service inspection activities and the results thereof through review of performance reports, reports on radiological safety aspects, event reports etc. required to be submitted by the utility.

ii. Regulatory Inspection

Compliance to the regulatory requirements is monitored by conducting periodic regulatory inspections. The regulatory inspections of NPPs are carried out during all stages of licensing to verify and ensure compliance to the regulatory requirements. During regulatory inspection, documented evidences for compliance to the regulatory requirements are examined and conduct of certain activities is witnessed. The regulatory inspections are carried out as per the guidelines given in AERB safety guide on ‘Regulatory Inspection and Enforcement in Nuclear and Radiation Facilities (AERB/SG/G-4)’. The provisions of the guide are elaborated in safety manual on Regulatory Inspections, (AERB/NPP/SM/G-1). Depending upon the requirements, AERB staff carries out periodic regulatory inspections as well as special unannounced inspections with specific objectives as deemed necessary.

During construction and commissioning stages, the inspections are carried out at a frequency of four inspections in a year. Regulatory Inspection team consisting of typically eight members carries out inspection for a period of about one week. Composition of team and areas to be inspected are pre-decided, taking into consideration the status of the project. In addition to normal regulatory inspections, AERB also identifies a list of important activities during construction and commissioning as hold points for which the licensee is required to inform AERB in advance for deputing its representative experts in the respective areas to witness these activities. As KK NPP-1&2 is the first PWR based NPP in India, AERB observers were deputed to provide regulatory surveillance during the commissioning activities of KK NPP-1&2 on continuous basis, in addition to routine regulatory inspections and deputation of the experts for witnessing important activities.

During operation stage, these inspections are carried out twice a year. In general, the following areas are covered during a typical regulatory inspection of an operating NPP.

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

Based on the inspection, a detailed inspection report is prepared and the utility is briefed about the findings in an exit meeting. The inspection findings are categorised according to their safety significance.

The regulatory inspection of physical protection systems for security of systems affecting safety of nuclear power plants is carried out once in a year. Special inspections are conducted during BSD of the NPPs to assess the radiological safety aspects. Special regulatory inspections are also carried out subsequent to an event, depending on the safety significance or after major modifications in the plant and form the basis for considering clearance for restart of the unit. AERB is considering increase in the on-site regulatory surveillance by various options, viz. deployment of on-site inspectors, deployment of dedicated inspectors at regional centers, and increasing the number of inspections by the staff at head quarter.

The regulatory guidelines of AERB have provisions to conduct unannounced inspection of NPPs for assessing the prevalent safety status at the NPP. Prior to the year 2013, few reactive inspections were conducted in unannounced manner. However, since 2013, AERB has been conducting frequent unannounced inspections. Specific requirements and guidance for unannounced inspections will be finalised after gaining sufficient experience on the outcomes of these inspections. Presently, the unannounced inspections are conducted based on the safety performance indicators that are being developed to monitor the performance of the NPPs and occurrence of important event or activity at the facility.

iii. Enforcement:

The utility is required to submit an action taken report within a specified time frame on the deficiencies pointed out during the inspection. These submissions are reviewed in AERB for disposition and need for any enforcement action. AERB may also initiate enforcement actions, if in its opinion the licensee has violated the conditions of the license willfully or otherwise or misinformed or did not divulge the information having bearing on safety after specifying the reasons for such actions. The enforcement actions may include one or more of the following:

a. A written directive for satisfactory rectification of the deficiency or deviation detected during inspection;

b. Written directive to applicant/licensee for improvement within a reasonable time frame;

c. Orders to curtail or stop activity;

d. Modification, suspension or revocation of license; and

e. Initiate legal proceedings under provisions of the Atomic Energy Act.

During the past three years AERB asked for satisfactory rectification of the deficiency in a number of cases. One such case where work was stopped was at RAPS-7&8 construction site after a fatality occurred on November 06, 2014. The jib of a tower crane collapsed during shifting of a bundle of reinforcement bars. A worker got trapped under the collapsed jib, and sustained severe injuries. The jib also got entangled with the nearby reinforcement bars in the yard, trapping the injured worker. The entrapped worker was subsequently brought out after arranging a mobile crane for lifting the collapsed jib and the reinforcement bars. The injured worker was given first aid and transferred to site hospital where he succumbed to his injuries. AERB suspended the operation of all material handling operations involving tower cranes at the site. AERB issued clearance for operations of tower cranes on December 17, 2014 after ensuring that the adequate measures were taken to avoid such incidents.

There were no such instances where an order for suspension of license was required during the reporting period. During safety review of nuclear power projects and related construction activities many written instructions for improvement within a reasonable time frame were given. All these enforcement requirements were complied with by the utility to the satisfaction of AERB.

14.3 OPERATIONAL EXPERIENCE FEEDBACK PROGRAMME

AERB as well as Utility have a structured system for reviewing external as well as internal OE pertaining to operating NPPs. The programme includes systematic collection of information, screening, review, dissemination and finally monitoring the implementation of the review recommendations. For reviewing international operating experience IRS reports received are screened and a group of experts review the screened reports. Screening guidelines have been developed to implement a graded approach in operating experience utilization. Review reports are prepared encapsulating the highlights. Events which demand further review are selected for discussion in a operating experience program.

Special Safety Reviews of all the Indian NPPs have been conducted following accidents such as Fukushima, TMI and Chernobyl and the incident of fire at Narora, India. The safety of all Indian NPPs is also assessed in view of the lessons learnt from incidents in NPPs within and outside India, e.g. flooding at Kakrapar in 1994, Tsunami at Kalpakkam in 2004, electrical fault at Forsmark in 2006, pressure tube leak in Kakrapar in 2016, etc.

The lessons learnt for safety enhancements in NPPs and improvement of regulatory practices are implemented in regulatory activities, such as design review, regulatory inspections & licensing process also, for meeting the complete intent of operating experience.

14.3.1 Special Safety Assessments following Fukushima

Subsequent to the accident at Fukushima NPPs, NPCIL conducted an immediate review to assess available capabilities to deal with the extreme external events by considering extended blackout and loss of ultimate heat sink provided in the existing design. AERB conducted an independent detailed review of plant specific design aspects with respect to functioning of safety systems and components and requirements for further enhancement of safety provisions in the case of extreme external events including combination of related events. The outcomes of these reviews were reported in detail in the National Reports for 2nd Extraordinary Meeting and Sixth Review Meeting of Contracting Parties.

The status of upgrades identified during these reviews is given in Article 6. During the last three years, AERB has reviewed the generic technical basis documents for accident management guidelines of PHWR based NPPs. Based on the review of this generic document, all PHWR based NPPs have prepared plant specific accident management guidelines and these have been reviewed by an Expert Group of NPCIL. The technical basis document for accident management guidelines of BWR reactor (i.e.TAPS-1&2) are under review in AERB. The reviews related to other provisions for mitigating consequences of severe accident, such as installation of hydrogen management provisions, provision for containment filtered venting system and creation of on-site emergency support centre are also in progress.

The regulatory response in the aftermath of Fukushima accident towards safety assessment and follow up of safety enhancement measures in Indian NPPs were also peer reviewed as part of the IRRS mission.

14.3.2 Safety Assessment of Indian NPPs in view of incidents of pressure tube leak at KAPS

The incidents of pressure tube leaks at KAPS units have been described in Article 6. While the root cause analysis and investigation of pressure tube leaks are in progress as elaborated in Article-6, the emphasis has been on ascertaining the safety of other operating units as well as units under construction.

Immediately after the incident at KAPS -1, AERB deputed its inspectors to KAPS for independent assessment of the safety status of the plant and radiological status. The Safety Review Committee for Operating Plants (SARCOP) and the unit level safety committee reviewed the event and safety status of the plant. The Board of AERB took stock of the event and the safety status as well as the reviews and actions being initiated by AERB and NPCIL to ensure the safety of other operating NPPs.

AERB mandated other operating NPPs to immediately conduct a thorough performance check of the AGMS as well as to sensitize operating staff at all NPPs to be more vigilant about the trend of dew point in AGMS. AERB also mandated all other operating NPPs to undertake expeditious inspection of coolant channels to assess their health.

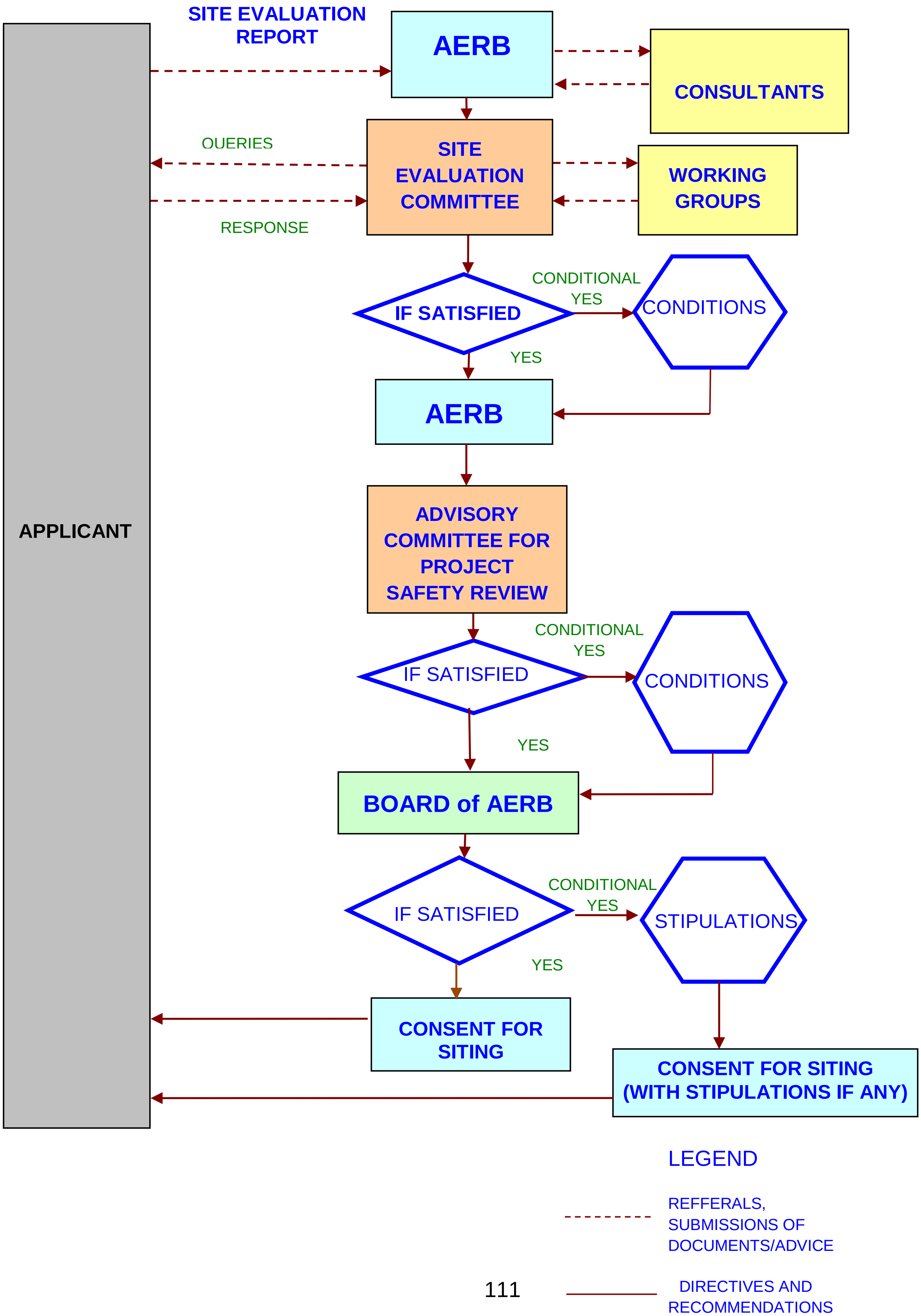
The inspections conducted at other operating reactors did not show any abnormality.

14.4 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

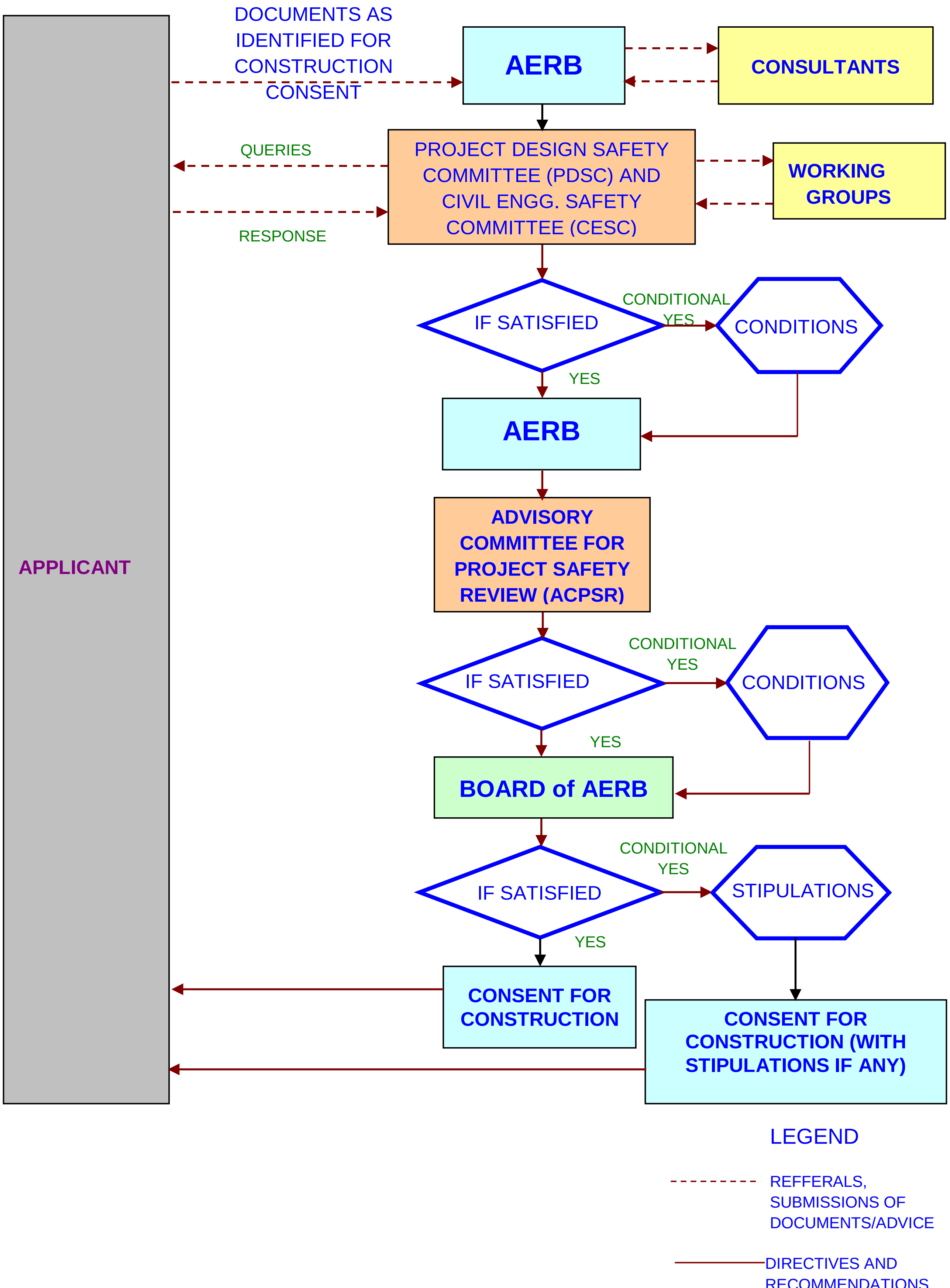
The consenting process established in the country ensures that comprehensive and systematic safety assessments are carried out during siting, construction, commissioning and operation. Changes that take place in the design during construction and commissioning are reflected in the FSAR, which forms one of the licensing documents. All the relevant documents are formally transferred to the plant management by the construction and commissioning groups by way of system transfer documents and construction completion certificate. Design modifications in the safety and safety related systems are carried out only after regulatory review and approval. Independent assessment and verification programmes are established both within the utility and the AERB. Adequacy and effectiveness of the assessment and verification programmes at the utility is ascertained by AERB through its regulatory control. During operation stage, the AERB checks that the verification programmes established at the NPP and the utility are adequate to demonstrate that the physical state and the operation of a nuclear installation continues to be in accordance with its design and applicable national safety requirements. Therefore, India complies with the obligations of Article 14 of the Convention.

The regulatory system in India already incorporates the necessary mechanisms which ensure that the review processes for new and existing NPPs take account of evolution in technology, regulatory practices and lessons learnt from operating experience. The review and verification mechanisms of the licensee and the regulatory body help India in addressing the Vienna Declaration on Nuclear Safety.

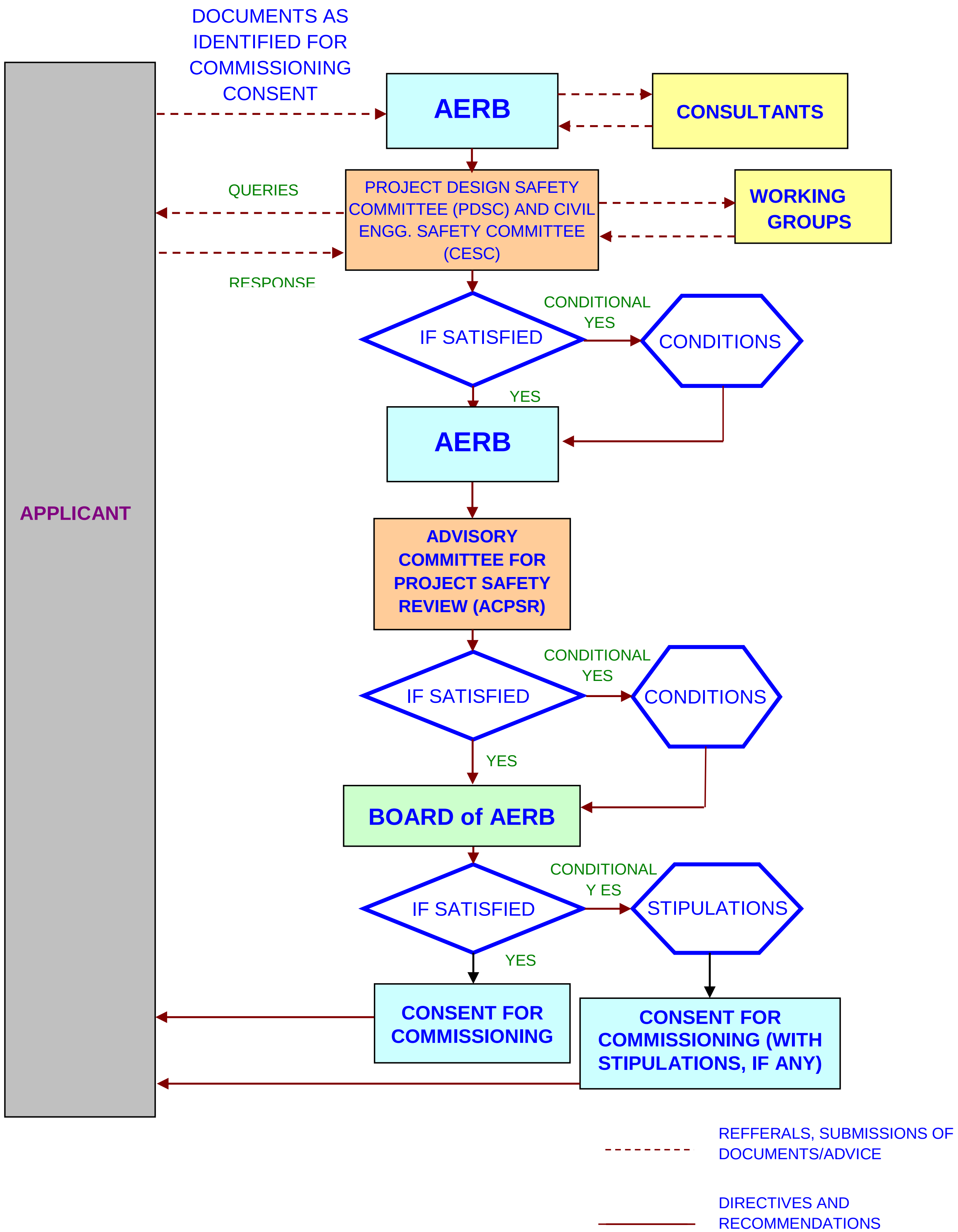
Annex 14-1: Scheme for Consent for Siting



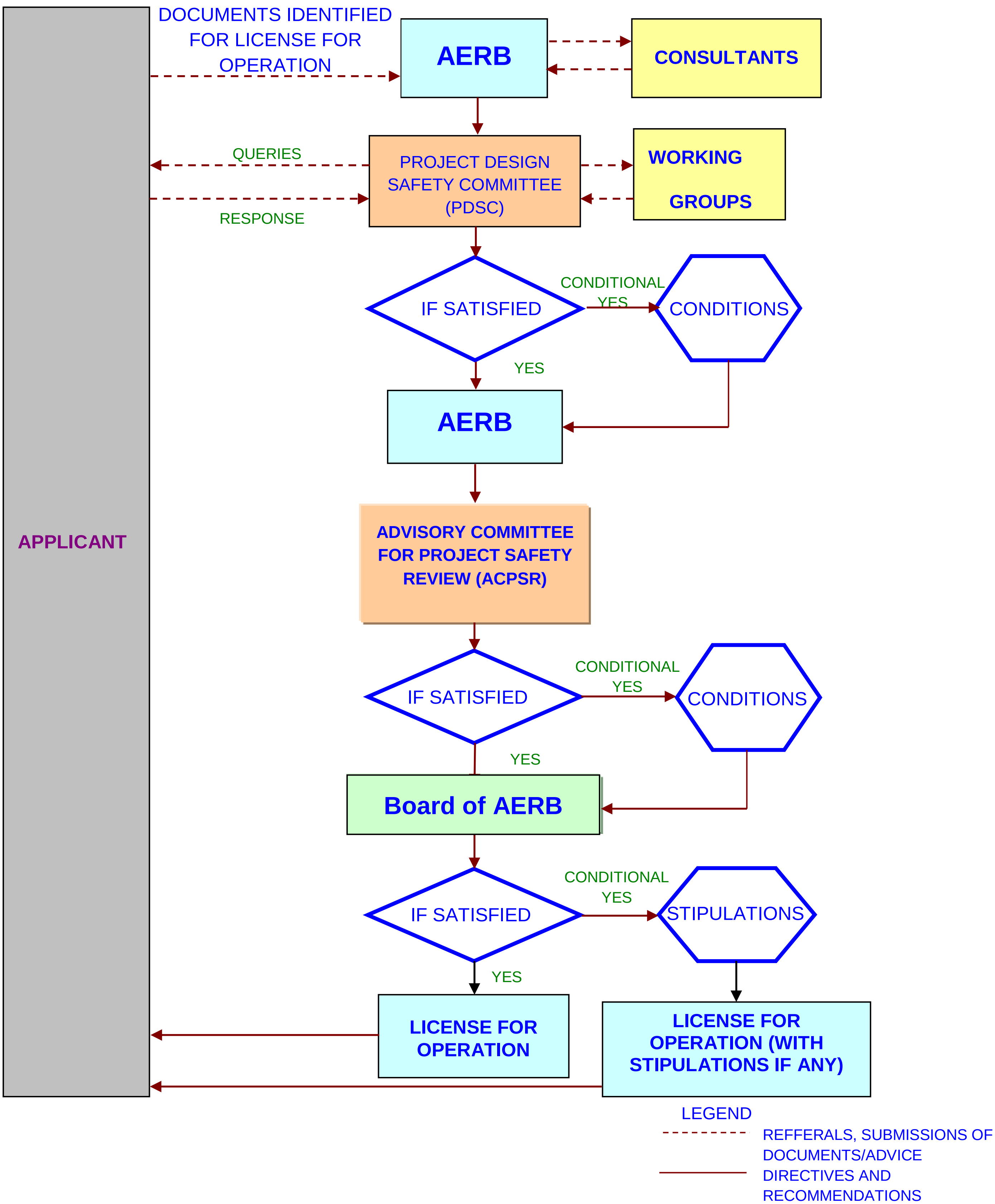
Annex 14-2: Scheme for Consent for Construction



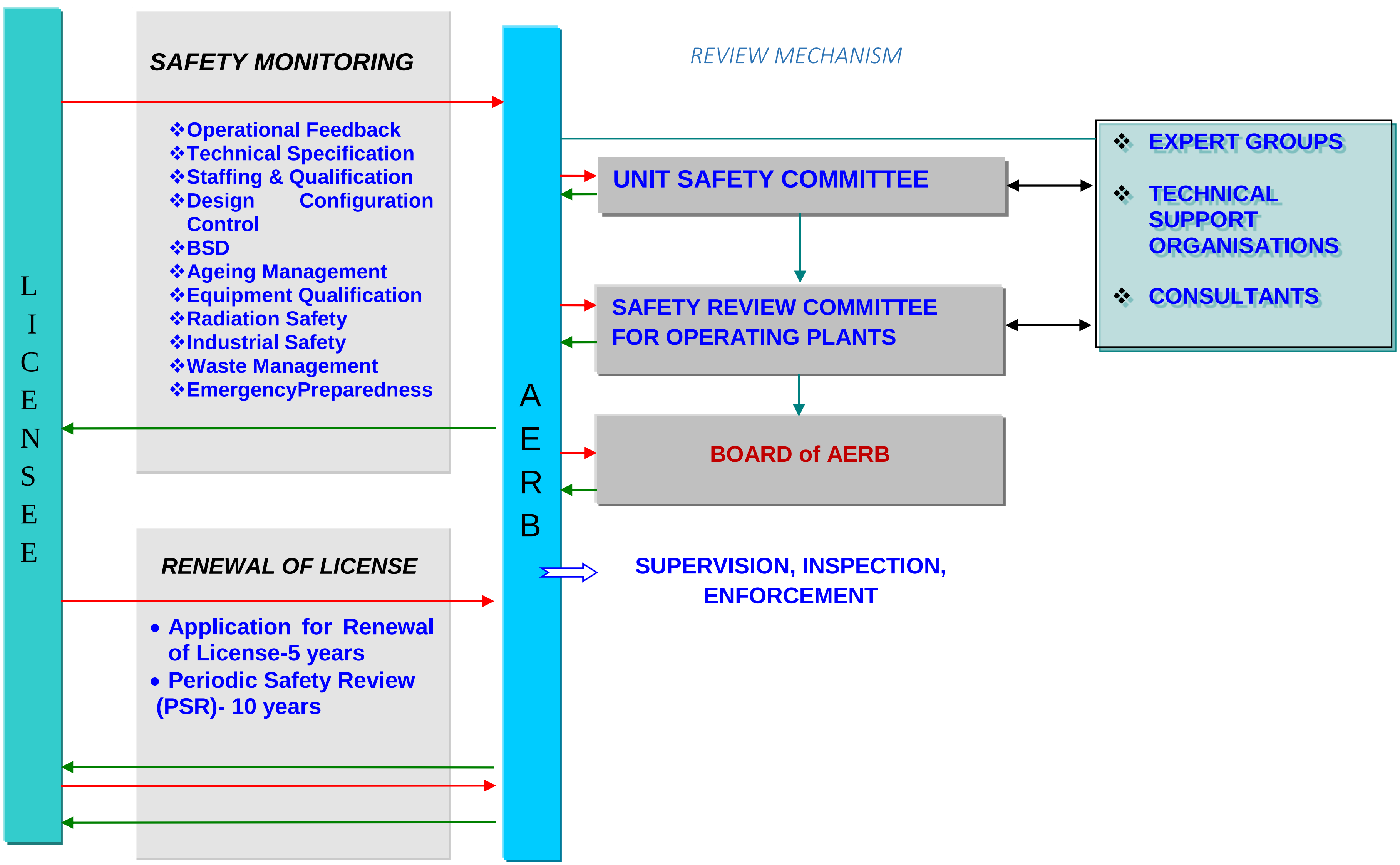
Annex 14-3: Scheme for Consent for Commissioning



Annex 14-4: Scheme for Consent for Initial Operation



Annex 14-5: Safety Review during Operation



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ARTICLE 15: RADIATION PROTECTION

Each Contracting Party shall take appropriate steps to ensure that in all operational states the radiation exposure to the workers and the public caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed the prescribed national dose limits.

15.0 GENERAL

Radiation Protection infrastructure and programme in all Indian NPPs is on sound footing and is strengthened on continual basis based on experience and technology development. The safety surveillance and regulatory mechanism of AERB in the area of radiation protection is comprehensive, continual and rigorous.

15.1 REGULATORY REQUIREMENTS RELATED TO RADIATION PROTECTION

Atomic Energy (Radiation Protection) Rules 2004 inter alia covers the requirements of radiation surveillance and its procedures, powers of inspection of radiation installation, sealing and seizure of radioactive materials and the duties and responsibilities of Radiological Safety Officers (RSO). In addition, the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules 1987 specify the requirements for safe disposal of radioactive wastes. AERB ensures compliance with the requirements under the above rules by all the nuclear and radiation facilities. Regulatory requirements for radiation protection for NPPs given in various Codes and Guides are as detailed below:

i) AERB Safety code on “Radiation Protection for Nuclear Fuel Cycle Facilities” (AERB/NF/SC/RP: 2012) covers radiation safety aspects specified in Atomic Energy (Radiation Protection) Rules, 2004 as applicable to the nuclear facilities.

   This safety code specifies the basic requirements for radiation safety of the occupational workers, members of the public and the environment. This code specifies the radiation protection requirements to be addressed in siting, design, construction, commissioning and operation of nuclear power plants. The requirements on radiation exposure control, discharge of radioactive effluents, radioactive waste monitoring, environmental monitoring, emergency preparedness, decommissioning and remediation are also addressed. The code also covers the roles and responsibilities of the consentee/ licensee, the Radiological Safety Officer (RSO) and occupational workers, and the quality assurance programme of radiation protection aspects.

   During preparation of this safety code, the safety requirements / guidelines provided in the IAEA documents, ICRP (ICRP 103, 2007) and the operational experience were considered.

ii) The Safety Code on Site Evaluation for Nuclear Facilities (AERB/NF/SC/S (Rev1), 2014) spells out the requirements to be met during siting of nuclear facilities for assuring safety including radiological safety. The code has been developed on the basis of relevant IAEA documents on Site Evaluation for Nuclear Facilities: Safety requirements. The code specifies the requirement of dose assessment, pathways and parameters to be used for dose assessment and dose criteria for various plant states as basis for plant design, for the site, among others.

iii) The Safety Code on Design for Safety in Nuclear Power Plants (AERB/NPP-PHWR/SC/D (Rev. 1) 2009) lays down the minimum requirements for ensuring adequate safety in plant design including radiation protection in NPPs. The guidance for implementation of radiation protection in the design of the nuclear power plants consistent with the requirements of the design code is provided in the “Safety Guide on Radiation Protection Aspects in Design for Nuclear Power Plants (AERB/SG/D-12, 2005)”. The guide covers the measures and provisions to be made in the design.

The Safety Code on Design for Safety in Light Water Reactors (AERB/NPP-LWR/SC/D 2015) lays down the minimum requirements for ensuring adequate safety in design of Light water reactors including radiation protection aspects.

Among other things, both these codes stipulate the provisions to be made in design to ensure adherence to ALARA principles and means/ methods to be employed for radiation monitoring.

iv) The Safety Code on Nuclear Power Plant Operation (AERB Code No. AERB/NPP/SC/O (Rev. 1), 2008) lays down the requirements including radiation protection to be met in order to achieve safe operation of a nuclear power plant. The code requires establishment of radiation protection programme prior to the commencement of operation of the NPP to ensure protection of site personnel, members of the public and the environment from the effects of ionising radiation.

The Safety Guide on Radiation Protection during Operation of NPPs (AERB/SG/O-5, 1999) provides guidelines for establishing an effective radiation protection programme. It focuses on the commitment of the Plant Management to follow the exposure control measures / ALARA exposure control during all operational states and accident conditions in the plant. Safety Manual on “Radiation Protection for Nuclear Facilities (AERB/SM/O-2 Rev.4, 2005) provides the technical and organizational aspects of occupational radiation exposure control under both normal and potential exposure conditions. Based on this each plant prepares its own “Radiation Protection Procedures” relevant to its design and functioning.

v) The Safety Code on Management of Radioactive Waste Site (AERB/NRF/SC/RW, 2007) lays down requirements to be met in the management of radioactive waste at nuclear and radiation facilities including radiation protection and environmental safety. The codes requires establishment of predisposal t the management of radioactive waste.

The dose limits for exposure from ionizing radiation for occupational workers and the members of the public are prescribed by AERB in its Directive No.01/2011under Rule 15 of the Atomic Energy (Radiation Protection) Rules 2004. These dose limits are as follows:

Dose Limits for Occupational Workers

a. an effective dose of 20 mSv/yr averaged over five consecutive years (calculated on a sliding scale of five years);

b. an effective dose of 30 mSv in any year;

c. an equivalent dose to the lens of the eye of 150 mSv in a year;

d. an equivalent dose to the extremities (hands and feet) of 500 mSv in a year and

e. an equivalent dose to the skin of 500 mSv in a year;

f. limits given above apply to female workers also. However, once pregnancy is declared the equivalent dose limit to embryo/fetus shall be 1 mSv for the remainder of the pregnancy.

ICRP (ICRP 118, 2012 and IAEA GSR Part-3, 2014) had recommended an equivalent dose limit to the lens of the eye as 20 mSv per year averaged over five consecutive years (100 mSv in 5 years) and of 50 mSv in any single year. AERB is in the process of collecting inputs from various stakeholders on identification of work practices having potential for eye lens exposure and their dose estimation and development of eye lens dosimeters for revising and implementing the regulatory dose limits for eye lens.

Dose Limits for members of public

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

15.2 RADIATION PROTECTION PROGRAM AT NPPs

15.2.1 Design Phase

The design of NPP is done with due regard to materials chosen for manufacturing, plant lay out and shielding requirements to meet the specified regulatory requirements of radiation exposures to the occupational workers and to optimize the collective radiation dose to the plant workers. Plant layout is optimized and areas are classified according to the expected radiation levels and potential for incidence of contamination in the area. Materials used in plant systems are selected in such a way that the activation products arising from the base material or the impurity content does not significantly contribute to radiation exposures during operation and also during decommissioning.

At the design stage, adequate provisions for radiation protection are made to keep radiation levels in plant areas below design levels. Ventilation system is designed in such a way that the airborne contamination is maintained below 1DAC in full time occupancy areas of the plant. Occupancy factors are also taken into consideration in the design of ventilation and shielding for the accessible areas of the plant. The shielding shall be such that the dose rate in full time occupancy areas does not exceed 1 µSv/hr. The NPP is also designed to comply with the specifications on radiation levels in plant areas, maximum radiation dose rates in control room and outside reactor building during accident conditions. It also has an elaborate radiation monitoring system to enable verification of design intent. Radiation Monitoring System consists of area radiation monitors, process monitors, environmental monitors and effluent monitors. These monitors are connected to a Radiation Data Acquisition System (RADAS) which gives history, trend and instantaneous readings of the monitors and displays their alarm state in plant control room and the shift health physicist's office.

Based on the operating experience, many design modifications for exposure control have been incorporated progressively in the Indian NPPs. Some of the design changes such as water filled Calandria Vault Cooling system, CO_2 based Annulus Gas Monitoring system, valve-less PHT system, use of sub-micron filters in PHT system, use of canned rotor pumps in moderator system, reduction of equipment/components in moderator and PHT systems, use of cobalt-free alloys in in-core components and relocation of some of the equipment e.g. vapour recovery dryers, end shield cooling heat exchangers etc. from Reactor Building to reactor auxiliary building have resulted in significant reduction in exposures.

Pre-Operational survey which includes monitoring of external radiation levels, assessment of radioactivity in water, air, soil and other environmental matrices, meteorological conditions, dietary habits of public etc. is carried out for a sufficiently long time during siting stage of NPP. This baseline data is subsequently used as a datum for radiological impact assessment due to NPP operation.

15.2.2 Operation Phase

Radiation protection programme during the operation of NPPs comprise of organizational, administrative and technical elements. ALARA measures are applied in exposure control of the plant personnel and the public. The plant management makes adequate review of the implementation and the effectiveness of the radiation protection programme. An effective environmental surveillance programme that provides radiological data to evaluate the impact of operation of the NPP on the surroundings areas of the plant site is established at each NPP. The main features of the radiation protection programme at the NPPs covers following elements:

- Organisational structure of the health physics unit at the NPP,
- Area/zone classification of plant areas and access control ,
- Exposure control scheme and work procedures,
- Area radiation monitoring and surveys,

- Environmental radiological surveillance and monitoring,
- Determination of external and internal doses,
- Decontamination procedures and methods ,
- Control, handling, storage and transport of radioactive materials including radioactive wastes,
- Control and monitoring of radioactive liquid and gaseous releases,
- Equipment for personnel protection,
- Training/retraining of personnel including temporary workers in radiation protection and emergency procedures,
- Health surveillance of radiation workers,
- Documentation of data on radiological conditions of the plant, personnel exposures and effluent discharges
- Training and qualification of health physics personnel, and
- QA programme.

i. Radiation Protection Organisation:

Each NPP has a Health Physics Unit (HPU), headed by a Radiological Safety Officer (RSO) and comprising of a group of trained and experienced radiation protection professionals. RSO in co-ordination with Plant Management implements the radiation protection programme in the plant. The requirements for RSO are stipulated by AERB according to which each NPP have identified RSO and alternate RSO under the Radiation Protection Rule- 2004 (RPR-2004). The HPUs are entrusted with the responsibility for providing radiological surveillance and safety support functions. These include radiological monitoring of workplace, plant systems, personnel, effluents, exposure control, exposure investigations and analysis and trending of radioactivity in the plant systems. The HPU functions are under the control of Directorate of Health, Safety and Environment at the utility Head Quarters and have direct channels of communication with the plant management in enforcing the radiation protection programme.

ii. Infrastructure and Manpower

The plant design provides radiation protection facilities such as clothing change room, personnel decontamination facility, equipment decontamination facility, transit waste storage room, storage facility for contaminated equipment/tools, active workshops, protective equipment servicing & testing area, active laundry, radiation data acquisition system and portal monitors.

The HPU is provided with trained and qualified man-power, adequate number of radiation monitoring instruments for normal and emergency use, laboratories and radiation instrument calibration facility.

iii. Exposure control and implementation of ALARA

All nuclear plants have radiation safety programs and work procedures intended to control the occupational exposures. Exposures to site personnel are controlled by a combination of radiation protection measures such as:

a) All NPPs have ALARA committees at station level and sectional level. These committees periodically review the plant radiological conditions and exposure status. The committees also review all dose intensive jobs planned at the facility and their recommendations are incorporated in the job planning. In addition, periodic ALARA reviews are conducted at the NPPs to identify areas for dose reduction and to implement corrective actions.

b) The operating experience on radiological events at NPPs in India and in other countries is reviewed and the lessons learned are communicated to all concerned station personnel. In addition, Station Operation Review Committee (SORC) also reviews the radiation exposure control.
c) Improved Collective Dose budgeting
d) Restricting the external exposure by means of shielding, remote operation, source control, rehearsing the work on mock ups and minimizing the exposure time;
e) Minimising the internal exposures by source control
f) Periodic review of radioactive work practices
g) Periodic training of radiation workers on Radiation protection aspects

iv. Observance of dose limits

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

All the radioactive works are performed under radiological work permit, which contains radiation level, air borne activity and surface contamination data. Accordingly, protective equipment, dose restrictions, time limits and additional precautions, if any, are recommended for controlling the dose.

The temporary workers employed for working in the controlled areas undergo pre-employment medical check-up and training in elementary radiation protection procedures. They are closely supervised by an appropriately qualified person during their work. A separate control constraint on dose and investigation levels is prescribed for temporary workers which are lower than that for the regular workers. The annual effective dose constraint for temporary radiation workers is 15 mSv.

The external exposure of radiation worker is determined using TLDs and for day to day dose control purpose Electronic Personnel Dosimeters (EPDs) with preset alarm facility are used. In areas of high or non-uniform radiation fields, additional dosimetry devices such as extremity badges (for hands or fingers) are used for control purpose. Neutron monitoring badges as prescribed by the health physics unit are used wherever applicable. Evaluation of the committed effective dose of all radiation workers due to tritium uptake in PHWRs is carried out by routine and non-routine bioassay sampling. Workers are also subjected to routine whole body counting for assessment of internal contamination.

A computerized dose data management system and National Occupational Dose Registry System is used in NPPs for effective dose monitoring and dose control of radiation workers. Networking of Radiation Monitors for obtaining radiation levels on real time basis is provided in the control room and the Health Physics office.

Around 14,900 persons were monitored annually during 2013-2015. The average annual dose of the monitored persons is 1.15 mSv. No radiation worker received the radiation dose above 20 mSv/year in the last three years.

15.3 CONTROL OF RADIOACTIVE EFFLUENTS

i. Method of Disposal and Monitoring

Gaseous wastes from reactor building are filtered using pre-filters and HEPA filters and discharged after monitoring, through ventilation exhaust stack. Whenever the effluent releases as monitored at final discharge points are below the minimum significant level of measurement, the average and total releases for a particular period are arrived by taking measurements in individual streams coming from active areas i.e. monitoring/sampling of individual exhaust streams is resorted**.** The release rate and integrated releases of different radionuclides are monitored and accounted for to demonstrate that the releases are within the authorized limits.

The radioactive liquid wastes generated in a NPP are segregated, filtered and conditioned as per procedure and diluted to comply with the discharge limits for aquatic environment. The activity is monitored at the point of discharge and accounted on a daily basis. If activity is not detected at main discharge point, then samples are taken from the disposal tank (prior to dilution) and analyzed in the laboratory for tritium and gross beta, gamma. The lab results along with the dilution flow are used to compute the activity discharged. In case, no activity is detected in the lab measurement, the Minimum Detectable Limit (MDL) of the counting system is used for arriving at the releases. AERB has prescribed limits on annual volume and activity of discharge, daily discharges and activity concentration at the point of discharge from each NPP and are site specific.

The radioactive solid wastes are disposed off in brick lined earthen trenches, RCC vaults or steel lined tile holes, depending on radioactivity content and radiation levels. These disposal modes are located in near surface disposal facility (NSDF) within the exclusion zone of NPP and disposal is carried out as per the guidelines enumerated in AERB/NRF/SG/RW-4, 2006.

The details on radioactive waste management are covered in the chapter on Article 19.

ii. Authorized Limits of Discharge

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

The regulatory limits (authorized limits) of radioactive effluents are based on the apportionment of effective dose limit of 1 mSv per year to the public arising from nuclear facilities at a site due to normal operation (including anticipated operational occurrences), considering all the routes of discharges and significant radionuclide in each route of discharge. There is also a requirement of maintaining sufficient ‘dose reserve’, while apportioning the doses among nuclear facilities at a site, to factor the future requirements.

The derived limits of effluent discharge corresponding to the dose apportioned for the facility for different radionuclides are established taking into account the site specific parameters, design of NPP and the operating experience, following the ALARA principle.

iii. Discharge constraints

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

15.4 ENVIRONMENTAL MONITORING

Environmental survey around each NPP site is carried out by Environmental Survey Laboratories (ESLs) of BARC. ESL is established several years prior to operation of a NPP. Extensive surveys are carried out around each Site to collect data on the dietary intake by the population. During the pre-operational phase, annual intake of cereals, pulses, vegetables, fish, meat, eggs and milk are established by direct survey. Elaborate studies of the topography of the site, land use pattern and population distributions are carried out systematically during the pre-operational phase. Along with the topographical and dietary studies, the ESL also carries out the work of establishing the pre-operational background radiation levels. Extensive micrometeorological data such as wind speed and wind direction, temperature and rain fall are collected for a few years to identify the predominant wind direction and the critical population.

The basic objective of environmental monitoring and surveillance programme is to assess the radiological impact under all states of the NPP and demonstrate compliance with the radiation exposure limits set for the members of the public by the AERB. This is achieved by carrying out radiological surveillance of the environment by professionals of ESLs. The ESLs are part of BARC and are independent of the utilities and submit periodic reports to AERB on radiological information and the results of environmental surveillance around the NPP.

The ESL continues its monitoring and surveillance programme during the operation phase of the NPP. The samples for analysis are selected on the basis of potential pathways of exposure. Areas up to a distance of 30 km distance are covered under the environmental survey programme. From the radioactivity level in the environmental matrices, intake parameters and dose conversion factors, the population dose is evaluated**.** The annual effective dose to the representative person of the public in the vicinity of the NPPs is estimated to be around 10 μSv, 40 μSv and 20 μSv for Tarapur, Rawatbhatta and Kalpakkam respectively, the three sites having old NPP units and 0.1 to 2μSv for other NPP sites.

Indian Environmental Radiation Monitoring Network (IERMON) has been established across the country for online detection of nuclear emergency. IERMON provides:

- On-line information about radiation levels at various locations in the country.
- Data on background environmental radiation levels and long term shift in the background levels.
- Data for environmental impact assessment following nuclear emergencies.

15.5 RADIOLOGICAL PROTECTION OF THE PUBLIC

AERB has prescribed effective dose (whole body) limit of 1 mSv per year to a member of public due to discharge of radioactive effluents from nuclear facilities at a site.

The sources contributing to generation of radioactive solid, liquid and gaseous wastes and their discharge to the environment are examined with respect to minimization of waste at the source at the design stage itself. The effluent discharges are continuously monitored and restricted within the authorized limits. In addition to the authorized limits of discharge AERB has prescribed “Discharge Constraints” at which the licensee is required to review the situation and report to AERB on the corrective actions planned. The dose to the public resulting from these releases is assessed and if necessary, appropriate design measures to reduce the discharge are introduced. The annual effective dose to the representative person in public domain at various distances is assessed by using radioactive liquid and gaseous discharges as well as radioactivity concentration in various environmental matrices around NPPs. The radiation level in the public domain of NPP site and discharges from NPPs are included in the annual report of AERB and placed on public website.

15.6 REGULATORY REVIEW AND CONTROL ACTIVITIES

AERB enforces control on radiation protection aspects of NPPs through

i. Review of Radiation protection aspects during Project Stage:

During the review of Preliminary Safety Analysis Report of the NPP at the project stage, aspects of radiation protection such as equipment layout, zoning, shielding, material selection etc. are covered. This ensures that during the subsequent operational stage of the NPP, exposure to occupational worker for Operational and Maintenance jobs are limited.

ii. Collective Radiation Dose Budgeting

Annually the collective dose budget is prepared by each NPP based on the jobs that are likely to be executed and collective dose consumed in the previous years as well as the existing radiological condition in the plant. The aim of the exercise is to minimize the collective dose in line with ALARA principle. AERB carries out review of the budget at Unit Safety Committee level followed by approval from SARCOP. The review is based on past experience of similar jobs and maintain parity between similar kinds of units. Further on quarterly basis adherence to the budget is also reviewed so that the planned activities for the year are carried out within the budget. Any upward revision of the budget requires adequate justification by NPP, review and approval by AERB.

iii. Review of Radiological Safety Aspects

Routine quarterly and annual reports on radiological safety aspects are prepared jointly by the RSO of the NPP and Directorate of HS&E at HQ of Utility. Subsequently, it is reviewed at Station level in SORC. This report is further reviewed at NPC-SRC for operations at HQ and submitted to AERB for review. The reports at AERB are reviewed by Unit Safety Committee and SARCOP. Necessary corrective measures, if required, are recommended to station.

iv. Regulatory Inspection

AERB carries out regulatory inspection of all NPPs every six months to verify the compliance with the safety requirements and to check radiological status. During the inspection environmental monitoring data, effluent discharge data, radioactive waste disposal data and quality assurance programme in Radiation Protection are checked. Additionally, AERB also conducts regulatory inspections during Biennial Shutdown (BSD)/ Refueling Shutdown (RSD) of NPPs to ascertain compliance with radiation protection procedures.

v. Review of Radiation Exposure to Occupational Workers

Radiation exposure to the occupational workers is controlled by ensuring compliance with the dose limits prescribed by AERB. The radiation exposure to the occupational workers is periodically reviewed by AERB based on the health physics reports. The exposure cases exceeding the regulatory constraints/ limits are primarily investigated by the exposure investigation committee at each NPP and subsequently by the AERB Safety Committees.

15.7 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

Appropriate laws, regulations and requirements regarding radiation protection as applicable to NPPs are in place and are being complied with by the utility. Adequate regulatory control is exercised by AERB, through the regulatory mechanism and respective organisations, application of dose limits, authorization for release of radioactive effluents, application of ALARA, environmental surveillance and regulatory inspections. Significant experience and expertise have been gained over the years for systematic implementation of radiation protection programme in NPPs. Therefore, India complies with the obligations of Article 15 of the Convention.

ARTICLE 16: EMERGENCY PREPAREDNESS

1. **Each Contracting Party shall take the appropriate steps to ensure that there are onsite and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency.**
2. **For any new nuclear installation, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.**
3. **Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the States in the vicinity of the nuclear installation are provided with appropriate information for emergency planning and response.**
4. **Contracting Parties which do not have a nuclear installation on their territory, insofar as they are likely to be affected in the event of a radiological emergency at a nuclear installation in the vicinity, shall take the appropriate steps for the preparation and testing of emergency plans for their territory that cover the activities to be carried out in the event of such an emergency.**

16.0 GENERAL

Nuclear Power Plants (NPPs) in India are designed, constructed, commissioned and operated in conformity with relevant nuclear safety requirements. These requirements ensure an adequate margin of safety so that NPPs can be operated without undue radiological risks to the plant personnel and members of the public. Notwithstanding these, it is necessary to develop Emergency Preparedness and Response (EPR) plans, as a measure of abundant caution. EPR plan has been an essential requirement for operation of NPPs in India from the very beginning of nuclear power programme. These plans are prepared in accordance with the national laws and regulations and deal with effective management of any eventuality with a potential to pose an undue radiological risk to the plant personnel and the public. The Plant Management and District Authorities / Local Government have a significant role in preparedness and response to emergencies.

16.1 NATIONAL LAWS, REGULATIONS AND REQUIREMENTS

The national legislative requirement for the use of atomic energy is governed by Atomic Energy Act 1962. Atomic Energy (Radiation Protection) Rules 2004 prescribe the rules for implementation of the radiation protection related provisions of this Act. The Rule No. 32 prescribes the directives in case of accidents and the Rule No. 33 prescribes the requirement for emergency preparedness. Government of India has also enacted “Disaster Management Act, 2005” which provides for effective management of disasters including accidents at NPPs which can result in a radiological emergency in the public domain. Based on these laws and regulations, specific requirements with respect to emergency preparedness in NPPs have been formulated by AERB.

The National Disaster Management Authority (NDMA) issued guidelines for ‘Nuclear and Radiological Emergencies in Public Domain’ in 2009 for effective management of Nuclear and radiological emergencies. The National Disaster Management Plan issued in year 2016 identifies the Dept. of Atomic Energy (DAE) as nodal agency for management of Nuclear and Radiological Emergencies. This plan assigns distinct functional responsibilities to various local, state and central authorities. As per this plan, AERB has the responsibility to prepare safety and regulatory documents for all nuclear/ radiological applications, transport, safe custody, waste handling, personal safety, medical aspects etc.

The constitution order of AERB (1983) also assigns it the responsibility for review of the emergency preparedness plans of Nuclear Facilities. In order to fulfill these responsibilities, AERB has published necessary guidelines for preparation of emergency preparedness and response plans for Nuclear Installations.

The Safety Guidelines “Preparation of Off-Site Emergency Preparedness and Response Plans for Nuclear emergency” (AERB/SG/EP-2, 1999) is under revision. Revised draft of AERB/SG/EP-2 has been issued by AERB for comments. This provides necessary requirements and guidance for establishment of off-site emergency preparedness and response plan for nuclear emergency in an effective, coordinated and integrated emergency response. This safety guideline provides general requirements, functional requirements and requirements for infrastructure for emergency response. The implementation of protective actions is based on generic criteria and operational criteria. This revised AERB Safety Guideline is in line with GSR-Part-7. The regulatory requirements with respect to off-site emergency declaration and responsibilities of site emergency director as a technical advisor to off-site emergency director is adequately addressed in this safety document. Also, regulatory requirements for licensees to test all emergency response functions over a determined period of time etc. have been provided in revised EP-2 (draft).

The regulatory requirements for preparing and maintaining emergency response plans for plant and site Emergency are given in the AERB Safety Guidelines “Preparation of Site Emergency Plans for Nuclear Installation” (AERB/SG/EP-1, 1999).

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

In addition to the above guidelines, aspects related with emergency preparedness and response are also covered in the following AERB safety documents,

- The Safety Code on “Regulation of Nuclear and Radiation Facilities” (AERB/SC/G, 2000) stipulates the minimum safety related requirements including that for emergency preparedness to be met by a nuclear or radiation facility to qualify for the issue of regulatory consent at every stage. Prior to issuance of license for operation of a NPP, AERB ensures that the approved emergency preparedness plans are in place and tested.
- The Safety Code on “Safety in Nuclear Power Plant Operation” (AERB/SC/O, 2008) stipulates the requirement for development of an emergency preparedness plan and maintenance of a high degree of emergency preparedness by the licensee. The emergency preparedness programme shall provide reasonable assurance that, in the event of an emergency situation, appropriate measures will be taken to mitigate the consequences. This programme has to be in force before commencement of operation.
- The Safety Code on “Radiation Protection for Nuclear Fuel Cycle Facilities” (AERB/NF/SC/RP2012) stipulates the requirements for providing adequate assurance for radiation safety of the occupational workers, members of the public and the environment against the undue exposure to ionising radiation. It also specifies the requirements for establishing emergency preparedness program and the roles and responsibilities of the various agencies.
- The Safety Guide on “Role of the Regulatory Body with Respect to Emergency Response and Preparedness at Nuclear and Radiation Facilities” (AERB/SG/G-5,2000) describes the role of the AERB with respect to emergencies at nuclear and radiation facilities. It provides necessary information intended to assist the facilities, and other participating/ collaborating agencies, to fulfill the requirements stipulated in the Code. It also elaborates on AERB’s review and approval process of the emergency response and preparedness plans formulated by the nuclear and radiation facilities and the review of the reports of the emergency exercises carried out to assess the adequacy of the response plans and the associated preparedness.
- The Safety Guide on “Preparedness of the Plant Management for Handling Emergencies at NPPs” (AERB/SG/O-6, 2000) supplements the Code on Safety in NPP Operation. It

covers the important considerations relevant to the preparation and implementation of EPR plans by the Plant Management.

16.2 EMERGENCY PREPAREDNESS AND RESPONSE PLANS

Successful demonstration of Emergency Preparedness and Response (EPR) plans is a mandatory requirement for issuing license for operation of NPPs. AERB ensures that necessary EPR plans are in place and they are successfully demonstrated before issuing regulatory consent for First Approach to Criticality. AERB evaluates all the elements of the EPR plans such as identification of emergency, classification, decision making, notification, communication, projected dose assessment and ensures the periodic revision of these plans. The regulatory oversight during plant operation assures that the provisions and procedures to implement these plans are maintained up-to-date and tested periodically. EPR plans cover all emergency situations envisaged so that a graded response consistent with the gravity of the situation can be ensured.

AERB reviews and approves plant and site emergency preparedness & response plans of NPPs. The off-site emergency plan is reviewed by AERB before it is approved by the district authority / state authority. District authorities in consultation with SED conduct off-site emergency exercises periodically at all NPP sites. In these exercises observers from other organisations such as AERB, Crisis Management Group-Department of Atomic Energy (CMG-DAE), NDMA, and NPCIL HQ also participate to check response of different emergency response groups as specified in approved EPR plans. During the above exercises, resources and facilities are assessed for adequacy. Further, NREMC at AERB is also activated to monitor these exercises.

Main features of the emergency preparedness and response plan are as follows:

16.2.1 Protective Actions

System of protective action is based on the projected dose and other response action (medical response) is based on the actual dose received. The emergency response plan takes into account the deterministic effects, stochastic effects and sociological impact during the implementation of protective actions.

The Generic criteria and operational criteria have been established and included in the site specific EPR plans of NPPs and are being used for implementation of protective actions. The generic criteria of greater than 100mSv/y is used for justified protective actions and 20-100 mSv/y is used for optimization of protective actions specified in revised AERB/SG/EP-2 (draft) and AERB/SG/EP-5 (2014). The reference level (residual dose) 20mSv/y is used for termination of emergency and transition from emergency exposure situation to existing exposure situation.

16.2.2 Emergency Planning Zones and Distances

Emergency planning zones and distances are established for emergency preparedness and response. The requirement and guidance for these zones and distances are provided in AERB Safety Codes AERB/SC/G, AERB/NF/SC/S, Rev. 1, 2014 and AERB/SC/O and AERB Safety Guidelines AERB/SG/EP-2(draft) and AERB/NRF/SG/EP-5, for drawing up the emergency preparedness and response plans for NPPs. For effective implementation of protective actions, the area around the site is divided into zones viz. Precautionary Action Zone (PAZ) and Urgent Protective Action Planning Zone (UPZ). The area is further extended in the downwind direction as Extended Planning Distance (EPD) and Ingestion and Commodities Planning Distance (ICPD) for implementing protective actions. For the purpose of emergency preparedness, sizes of the zones & distances are based on hazard analysis. However, in actual emergency situations, these zones and distances will get established based on hazard category, anticipated / actual radioactivity release, meteorological parameters and time required for effective response action(s).

16.2.3 Classification of Emergencies

In accordance with the severity of the potential consequences, emergency situations are graded as Plant Emergency, Site emergency and Off-site emergency. Emergency Action Levels (EALs) are used for identification, classification and declaration of plant, site and off-site emergency. These EALs are the specific plant parameters and conditions established based on hazard analysis and included in site specific EPR plans.

i. Plant Emergency
It is an emergency condition identified by EALs, in which the radiological/other consequences are confined within the plant or a section of the plant. The Plant Emergency Director (Station Director) is identified as the responsible person for the declaration and termination of a plant emergency.

ii. Site Emergency
It is an emergency condition identified by EALs, in which the radiological consequences are confined to the exclusion zone of the site. Site Emergency Director (SED) is the responsible person for the declaration and termination of a site emergency. Site Emergency Response Committee (SERC) advises SED. For twin unit site, Station Director and for multi-unit site, Site Director is identified as SED.

iii. Off-Site Emergency
It is an emergency condition resulting in an actual release, or substantial probability of a release, requiring implementation of urgent protective actions beyond the site boundary (exclusion zone) into the public domain. Off-Site Emergency Director, who is a district authority, is identified as the responsible person for the declaration and termination of an Off-Site emergency. Site Emergency Director (SED) provides technical inputs and assistance to district authority and recommends on implementation of protective actions and other response actions.

16.2.4 Features of On-Site EPR Plan

The Plant Management establishes and maintains the necessary emergency resources and procedures for implementation of On-Site EPR plan (i.e. Plant and Site EPR plans). The On-Site EPR plan includes criteria for declaration of emergency, duties and responsibilities of relevant key personnel, infrastructure for emergency response, mock exercises, and training of plant personnel & public authorities. Main elements of On-site EPR plan are detailed below:

16.2.4.1 Criteria for declaration and termination of emergency

Plant/ Site emergency is declared if the emergency action levels (EALs), which are plant parameters / conditions are such that actual or projected dose within the plant/site boundary is likely to reach emergency reference level as specified in the EPR plan.

The emergency is terminated after ensuring that the following conditions are met:

i. The plant condition is under control.
ii. The sources of incident causing emergency within the plant have been located and confined/ restricted.
iii. Effluent releases from the plant are within acceptable limits.

16.2.4.2 Infrastructure for On-Site Emergency Response

The infrastructure available for conducting various emergency response actions in a systematic, coordinated, and effective manner is as follows:

i. Plant Control Room
In case of plant emergency, the plant control room is identified as the centre to handle emergency operations. Further, in case of site emergency, the plant control room provides firsthand information about the emergency situation to the Site Emergency Response

Committee (SERC). If for some reason, the main control room becomes uninhabitable, the status of plant can be monitored from the backup control room.

ii. Site Emergency Control Centre (SECC)
Presently an Emergency Control Centre (ECC) for Site Emergency is suitably located away from the plant but within the site, for use by the Site Emergency Committee to direct emergency actions. Further, it is used for coordinating with off-site emergency authorities, so that control room staff is not distracted from performing control room operations. This facility houses emergency equipment centre, treatment area, personnel decontamination area and has sufficient space to accommodate SERC members, rescue teams, health physics staff, emergency maintenance unit staff, stores and industrial safety group. It is equipped with communication systems, public address system, emergency equipment/instruments, standard operating and emergency procedures, design basis reports, P&I diagrams, maps of EPZ, potassium iodate tablets, iso-dose curves etc for undertaking emergency response actions. In addition to above features, OESC details are given in sec 16.5.2.

iii. Communication System
The NPPs have diverse communication systems which are available for emergency purpose. Direct communication link is available between the emergency control centre, fire station and plant control room for communication within the plant. In addition, during on-site emergencies NPCIL/Utility Headquarters, CMG-DAE, AERB and District Authorities with Off-Site/local government are required to be kept informed for which, NPPs have redundant and independent communication system in place. The contact details of the identified key personnel are maintained and updated from time to time by the NPPs. Siren and announcement system with adequate number of points for warning the plant personnel are available. The declaration and termination of emergency is done though this system. Communication system includes wireless, telephone, radio sets, satellite communication and electronic mail facilities which are tested daily to ensure their availability. These systems are available for use at all times.

iv. Emergency Equipment and Protective Facilities
Various equipment required for emergency management are kept available in the NPP. To protect the plant personnel essential facilities such as plant assembly areas, emergency shelters, first-aid centre, treatment areas, de-contamination kits, prophylactics, respirators, ambulance etc. are provided within the site area. In addition, for monitoring the radiological conditions, the required number and type of radiation monitoring instruments are available.

16.2.4.3 Roles and Responsibilities for On-Site Emergency Response

For management of on-site emergency in an effective manner senior officers of the NPPs are identified and various response teams/groups are formed. These teams/groups are responsible for specific actions such as advisory, services, damage control, search, rescue, radiation monitoring, medical response, transportation, environmental survey etc. For effective coordination between these response teams a Site Emergency Committee is constituted with heads/ responsible persons from various sections of the plant. Site Director / Station Director is the head of the Site Emergency Committee. The duties and responsibilities of key personnel are well defined in the Site EPR plan.

16.2.5 Features of Off-Site EPR Plan

The offsite emergency plan includes details about site characteristics, procedures for declaration of emergency, duties and responsibilities of relevant key personnel, infrastructure for emergency response, requirements for exercises, and training of plant personnel & public authorities / Local Government. Main elements of off-site EPR plan are as detailed below:

16.2.5.1 Site Characteristics

The site characteristics that need to be detailed in the emergency preparedness plan are specified in the AERB guide "Preparation of Off-Site Emergency Preparedness and Response Plan for Nuclear Emergency" (AERB/SG/EP-2). This broadly covers geographical, meteorological and demographic characteristics of the site. Demographic characteristics of the site include population distribution within the emergency planning zone (EPZ), transient population, population density, population centres and special groups, if any. In addition, arrangements for evacuation taking into consideration the condition of main and alternate routes, shelter points, adverse weather condition, and traffic congestion etc. are covered.

16.2.5.2 Criteria for Declaration and Termination of Emergency

"The criteria for identification, classification and declaration of emergency are predefined emergency action levels (EALs) that relate to abnormal conditions in the facility, releases of radioactive material, environmental measurements and other observable indications". These criteria are derived from the generic criteria. The accidents in nuclear installation detected by plant and process parameters i.e. EALs which may lead to very high release of radioactivity in the public domain and have potential to deliver dose to the members of public in excess of reference levels forms the basis to declare an offsite emergency. The protective actions are implemented based on the generic criteria.

As part of emergency preparedness plan it is also ensured that arrangements are in place for the termination of a nuclear or radiological emergency. The termination of a nuclear or radiological emergency is done based on a formal decision that is made public and includes prior consultation with all stake holders, as appropriate. Both radiological consequences and non-radiological consequences are considered in deciding on the termination of an emergency. The off-site emergency is terminated after ensuring that the following conditions are met:

(a) Arrangements for managing the existing exposure situation are in-place.

(b) Justified protective actions have been taken to reach the target dose of 20 mSv per annum

(c) Confirmation that the source of exposure is fully characterized for normal living of members of the public

(d) The plant is under control and the sources of radiation within the plant have been identified and controlled.

16.2.5.3 Infrastructure for Off-Site Emergency Response

The infrastructure for implementing the emergency response actions in a systematic, coordinated, and effective manner is as follows:

i. Off-Site Emergency Control Centre
An Emergency Control Centre for the off-site emergency is located outside the exclusion zone. This is equipped with the required facilities for handling off-site emergency response operation and is used during Off-Site emergency for monitoring and directing offsite emergency response operation.

ii. Communication System
The Off-Site Emergency Control Centre of NPPs have redundant and independent communication systems for communication with NPCIL Headquarters, CMG-DAE, AERB and other concerned authorities/agencies. Emergency Communication Rooms (ECRs) of CMG-DAE are maintained at Mumbai at two different locations. These ECRs are equipped with wireless, telephone, facsimile, satellite communication and electronic mail facilities which are tested daily to ensure their availability.

iii. Assessment Facilities

The facilities required to assess the nature and severity of an incident and its impact on the environment are available at the NPP Site. These include plant parameters (EALs), Decision Support System (DSS), dose projection models, environmental survey vehicles, radiation survey and contamination monitors, dosimeters, meteorological data loggers, iso-dose curves, air samplers, maps, standard operating procedures, design basis reports, process & instrumentation diagrams.

iv. Radiation Monitoring during Emergency

Detailed procedures and the required capability for radiation monitoring of the affected population and area during an emergency are available at the Environmental Survey Laboratory (ESL) attached to each NPP site. Meteorological information and model predictions to determine the geographical area likely to be affected by the release of radioactive material provided by ESL is utilized to identify the monitoring and sampling locations. Projected dose / Radiological data required for taking decision on implementation of protective actions with reference to corresponding operational interventional levels (OILs) related with generic criteria (GC) are established.

v. Emergency Equipment and Protective Facilities

Various equipment required for emergency management are kept available in emergency equipment centre located in the plant as well as offsite emergency control centre. The equipment such as ambulance, decontamination centers., respirators, emergency equipment kit, personnel protective equipment and emergency power supplies are available In addition, for monitoring the radiological conditions, the required number of instruments such as, radiation survey instruments, iodine and particulate sampler, contamination monitor and emergency survey vehicle etc. are available at NPPs and Off-Site Emergency Control Centre.

To protect the plant personnel, site personnel and members of public during emergency situation, facilities such as plant assembly areas, temporary shelters, first-aid centre, decontamination centre, medical management centers / radiation emergency ward, psychological counselling, prophylactics, communication facilities, thermo luminescence dosimeters (TLDs), direct reading dosimeters (DRDs) and protective clothing etc. are available.

16.2.5.4 Roles and Responsibilities for Off-Site Emergency Response

EPR plans, wherein the roles and responsibilities of various agencies are defined, have evolved over the years for the existing NPPs. There is Off-site Emergency Committee headed by the Collector of the concerned District and supported by district subcommittees which ensures implementation of protective measures such as, sheltering, distribution of prophylactics, evacuation, providing civil amenities and maintaining law and order.

The national framework on EPR for nuclear and radiological emergency involves NDMA, as the apex body, which is mandated to lay down the policies, plans and guidelines for Emergency Management to ensure timely and effective response to disasters. NCMC, as an apex body, is for co-ordination at national level through its nodal agency i.e. CMG.

CMG-DAE is nodal agency of DAE for technical support & advice to district authority. District authority (DDMA) / District Collector implements protective actions in public domain based on generic criteria specified in the EPR plan. Licensee takes mitigatory actions within plant to minimise the consequence of the event, he also advises district authority on initiating protective actions in public domain based on the assessment and progression of the event. AERB develops safety codes, guidelines and guides on EPR and provides regulation and guidance for emergency preparedness and response. The roles & responsibilities and co-ordination mechanism of above agencies are well defined and documented.

The roles and responsibilities of various agencies involved in EPR plan for Off-site Emergency are as follows:

i. National Level

The national agencies such as National Disaster Management Authority (NDMA), National Crisis Management Committee (NCMC) and others response organizations have a role in management of all types of disasters including nuclear /radiological emergency which is as follows:

a. National Disaster Management Authority (NDMA) - NDMA, the apex body is headed by the Prime Minister of India and has the responsibility for laying down policies, plans and guidelines for disaster management in the country. NDMA assists the Central Ministries, Departments and States to formulate their respective disaster management plans. This provides National level organized response for assistance, harmonised approach to command and control responses in case of disasters including Nuclear emergency.

The NEC is the executive committee mandated to assist the NDMA in the discharge of its functions and also ensure compliance of the directions issued by the Central Government. The NEC coordinates the response in the event of any emergency. The NEC prepares the National Plan for Disaster Management based on the National Policy on Disaster Management and monitors the implementation of guidelines issued by NDMA.

National Disaster Response Force (NDRF) is constituted under DM act for handling all kinds of disasters. This is a multi- disciplinary, multi-skill, high-tech force. Twelve battalions have been equipped and trained for handling natural disasters including eight battalions for dealing with nuclear/radiological emergencies.

b. National Crisis Management Committee (NCMC) - The NCMC, under the Cabinet Secretary, is mandated to co-ordinate and monitor the response to crisis situations, which includes all disasters. The NCMC consists of 14 union secretaries of the concerned ministries including the Chairman, Railway Board. NCMC provides effective co-ordination and implementation of response and relief measures in the wake of disasters. It will be supported by the Crisis Management Groups (CMG) of the Central Nodal Ministries and assisted by NEC as may be necessary. The Secretary, NDMA is a permanent invitee to NCMC.

c. Crisis Management Group (CMG), DAE - Department of Atomic Energy (DAE) is the nodal agency in the country for providing technical expertise / guidelines for managing nuclear and radiological emergencies in the public domain. For this purpose, a Crisis Management Group (CMG) has been established in DAE since 1987. It is empowered to mobilize the resources of other DAE facilities, if required. CMG-DAE comprises of senior officials drawn from different DAE units and AERB.

In the event of “Off-Site Emergency”, all the Members and Alternate Members of the CMG, DAE, key officials in Mumbai, and the Secretary (Security), Cabinet Secretariat are intimated. CMG-DAE provides necessary co-ordination between local authorities in the affected area(s), the NDMA and NCMC and arranges necessary technical support for effectively handling the situation and reducing radiation exposure to the public. CMG provides advice and assistance in the areas of radiation measurement, radiation protection and medical assistance in the affected area. The Emergency Communication Room (ECR) located at DAE Headquarter, Mumbai & at NPCIL, Headquarter, Mumbai functions 24 x 7 and ensures communication and co-ordination between all relevant agencies. The Secretary (Security) is the contact point for DAE with the NCMC.

d. Technical Support Organisation (TSO) - Director, Health, Safety & Environment (HS&E) Group, BARC who is the ex-officio Emergency Response Director (ERD) of DAE is the lead co-coordinator for providing the radiation measurement, monitoring and protection services to the CMG, DAE. A network of twenty-three radiation Emergency Response Centres (ERCs) equipped with adequate radiation measuring and personnel protective equipment and trained Emergency Response Teams (ERTs) have been established by Department of Atomic Energy (DAE) in different parts of the country to respond to nuclear and radiation emergency situations. ERD also establishes the Standard Operating Procedures (SOPs) and co-ordinates with the concerned responsible officers of various locations. During nuclear and radiological emergency situation, the ERC closest to the site of the incident, will be activated by the ERD.

The HS&E group, BARC has established Indian Environmental Radiation Monitoring Network (IERMON) at various parts of the country and with central monitoring station located in Mumbai. IERMON provides online environmental radiation information during both normal and emergency situations.

e. Environment Survey Laboratory (ESL) - A well-equipped Environment Survey Laboratory (ESL) is established at each nuclear power plant site by HS&E group of BARC (TSO) well before the commissioning of the plant and continues to remain functional during the operational phase of NPP. During nuclear emergency ESL, initiates environmental surveillance outside the exclusion boundary for monitoring any change in environmental radiation levels. It also provides information on meteorological data such as wind speed, wind direction etc. It undertakes extensive environmental sampling and radiation surveillance in the affected sectors to facilitate decisions regarding protective measures to be implemented in the public domain. It also provides predictive dose (based on source term and meteorological conditions) to the Site Emergency Director. These ESLs are integral part of the response organisations at each NPP sites.

f. Atomic Energy Regulatory Board (AERB) - AERB lays down the requirements and provides guidance for preparation of EPR plans (see section 16.2.7). AERB reviews and approves plant and site emergency preparedness & response plans of NPPs. The off-site emergency plans are reviewed by AERB to ensure regulatory compliance before being approved by the district authority/state authority. It ensures EPR plans are in place prior to the operation of NPP and are periodically updated. It further ensures that the plans are tested through periodic exercises as prescribed by AERB codes and guides and participates, as an observer, in the exercises.

During nuclear emergency phase, AERB monitors and keeps the interface with CMG-DAE, District authorities and licensee. It reviews & assesses the emergency situation as necessary, and if required, advises or issues directions to response agencies to further improve the mitigatory efforts and inform the public on emergency situations. For this purpose, AERB maintains its own Nuclear and Radiation Emergency Monitoring Centre (NREMC) which is equipped with adequate communication facility and capability to independently assess the emergency situation.

During the existing exposure situation, AERB reviews and advises follow up actions to minimize exposures to protect the public, lays down criteria for re-entry into plant areas and affected places and review resumption of operations or decommissioning of the facility.

ii. State Level

The State Disaster Management Authority (SDMA) headed by the Chief Minister of the State as Chairperson lays down policies and plans for Disaster Management in the State. It approves the State Plan in accordance with the guidelines laid down by NDMA, coordinates the implementation of the State Plan, recommends provision of funds for mitigation and preparedness measures and reviews the developmental plans of the different departments of the State to ensure integration of prevention, preparedness and mitigation measures.

Each State Government constitutes a State Executive Committee (SEC) to assist the SDMA in the performance of its functions. The SEC is headed by the Chief Secretary (CS) to the State Government, coordinates and monitors the implementation of the National Policy, the National Plan and the State Plan. The SEC also provides information to the NDMA relating to different aspects of Disaster Management.

iii. District Level

District Disaster Management Authority (DDMA) is the overall in-charge for the management of off-site emergency. DDMA acts as the planning, coordinating and implementing body for management of all types of disasters at district level including nuclear/radiological emergency in public domain (offsite emergency). DDMA is headed by the District Magistrate, District Collector (DC), Dy. Commissioner as the case may be.

All the decisions related to management of emergency in public domain are taken and executed by the Off-Site Emergency Committee. The Chairman of the Off-site emergency committee is (District Collector / Magistrate) and is responsible for declaration/ termination of an Off-site Emergency, in consultation with the Site Emergency Director, who is a Member of the Off-site Emergency Committee. It takes all necessary measures for emergency management in accordance with the policies, guidelines and plans laid down by SDMA, NDMA & AERB. The DDMA also ensures that the guidelines for prevention, mitigation, preparedness and response measures laid down by AERB, NDMA and SDMA are followed by all departments of the State Government at the district level and the local authorities in the district. In an emergency situation, the district authority on receipt of notification, initiates prompt response actions to protect public and responders based on technical inputs from SED. Thus the DDMA coordinates with all responsible agencies such as NPP, SDMA, CMG-DAE, NDMA, AERB and NDRF.

iv. Roles and Responsibilities of the Operating Organisation

In an emergency situation, the licensee reviews the plant status and assesses the actual or projected releases from the plant to identify and classify the emergency category. Plant and Site emergencies are declared by Licensee while Off-site emergency is declared by district authority based on technical inputs from Licensee. Emergency communication are sent promptly to district authority (District Collector)) and other concerned organisations including AERB, CMG-DAE and NPCIL HQ. Site Emergency Director (SED) provides technical inputs and assistance to district authority and recommends on implementation of protective actions and other response actions.

16.2.6 Training and Exercise

The required emergency preparedness is maintained by organizing refresher training courses for site and off-site personnel at regular intervals. This includes conducting periodic exercises / rehearsals involving all concerned personnel of both site and off-site, updating plant emergency procedures at a specified frequency, making suitable changes in the plan in the light of periodic reviews based on emergency exercises and keeping all emergency equipment and accessories in ready state.

i. Training

Appropriate training is imparted at regular intervals to all employees of the NPP, to familiarize them with actions that should be taken during an emergency. Similar training courses are also organized for various Public Authorities. Public awareness programmes are organised for various public authorities and members of public for familiarization on radiation protection procedures and response actions during emergency.

Training programmes are also organised for National Disaster Response Force (NDRF) personnel in radiation protection procedures and response actions during nuclear and radiation emergency. The training is aimed at qualifying persons to act as trainers in their respective battalions. An arrangement has been put in place through which the training needs of personnel are identified by NDRF and special training and awareness programmes are arranged as necessary with support from BARC, NPCIL and AERB.

ii. Exercises

Exercises are conducted at regular intervals and all response organizations / concerned agencies take part. Exercises are used for the twin purposes: a) familiarize all the personnel concerned with the management and implementation of emergency measures b) assess the adequacy of EPR plans and improve them based on the feedback from exercises. It is also ensured that each Shift Crew of the plant takes part in these exercises at least once a year. The site emergency exercises and off-site exercises are conducted in accordance with the frequency prescribed by AERB. The frequency of plant, site and offsite emergency exercises are once in three months, once in a year and once in two years respectively. The observations made in each exercise are reviewed by the responsible agencies and deficiencies are promptly corrected.

In emergency exercises, hypothetical events resulting in off-site radiological implications are considered and efficacy of protective measures such as sheltering, distribution of prophylactics, sample evacuation is tested. Off-site exercises are conducted once in every two years at each site as per regulatory requirements. Based on the feedback from review of the exercise results, improvements in the infrastructure and other facilities are initiated, if necessary. Compliance to these aspects are further verified by AERB.

16.2.7 Harmonization of EPR Plans

AERB Safety Guidelines on EPR, AERB/SG/EP-5 is in line with latest published IAEA safety documents on EPR (GSR part-7, GSG-2.1, GSG2 and GSR part-3) which ensures harmonization of EPR plans with international practice. In addition, AERB has revised the Safety Guidelines “Preparation of Off-Site Emergency Preparedness and Response Plans for Nuclear emergency” (AERB/SG/EP-2) based on recently issued GSR part-7 to make the approach consistent with IAEA. This revised draft has been circulated for comments to all NPPs. Along with the approval process of AERB/SG/EP-2, the work on harmonizing EPR aspects in related AERB Codes and other documents is being taken up.

The requirements and guidance laid down in AERB/SG/EP-5 is being implemented in site specific EPR plans of NPPs. Also, NPPs are updating the EPR plans taking into account requirements and guidance given in the AERB/SG/EP-2 (draft). The revised regulatory guidelines (AERB/SG/EP-2, draft) and site specific EPR plans adequately address the EPR aspects of 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.

16.3 IMPLEMENTATION OF OFF-SITE EMERGENCY MEASURES

The emergency measures consist of actions with respect to identification, classification, declaration and notification of emergency; assessment of emergency situation; corrective actions; mitigation actions; protective actions and control of contamination. These are detailed in the Off-site EPR plan and are described below:

16.3.1 Emergency Response Actions

The general sequence of response actions during an emergency:

i. Identification, Classification and Declaration of emergency

At the incipient stage of an accident, based on the adverse plant parameters and conditions (EALs), plant emergency is declared by station director as per the criteria specified in the EPR plan. If the condition further worsens and if actual or projected releases are likely to be within the site boundary, Site Emergency Director (SED) declares the Site Emergency. At this stage, the Offsite Emergency Director (OED) is alerted about the possible escalation of Site Emergency in to Off-Site Emergency and if the situation further worsens, SED advises the OED to declare Off-Site emergency and initiate protective actions in the emergency planning zone

ii. Assessment Action during Emergency

The assessment of the plant conditions and likely radiological releases are made to enable planning corrective actions and timely implementation of protective measures. The information used for assessment is based on plant parameters available in the main control room, Decision Support System (DSS), dose projection models, radiation surveys, environmental surveys and meteorological data among others. Each NPP has established facilities to continuously monitor the wind and weather conditions and to obtain dose projections in the public domain that could form the basis for determining the suitable protective measures. Provisions are also available for establishing the source term by actual measurement. In addition, the information from the Indian Environmental Radiation Monitoring Network (IERMON) is used for assessment of radiation levels in the public domain.

iii. Co-ordination among various agencies

On receiving the information of Offsite emergency from Station Management, CMG-DAE is activated. While the offsite emergency director initiates actions as per action plan for handling the emergency in public domain, the CMG will continue to provide necessary coordination between local authorities in the affected areas, the NDMA and National Crisis Management Committee (NCMC) and will provide necessary technical support and directions to the authorities responsible till the emergency conditions are terminated. On the prevailing situation at incident site, the information to the media and other agencies are given by Information and Media Officer appointed by District Collector (i.e. Chairman, Off-Site Emergency Committee).

iv. Mitigatory / Corrective Actions

These actions are taken to mitigate / correct the plant abnormal situation and to bring the plant under control. Various corrective actions are taken in accordance with the Emergency Operating Procedures and AMG actions existing in the plant.

v. Protective Measures

These are actions taken to mitigate the consequences of a radiological event and to protect site personnel, members of public and livestock from radiation. On the time scale these protective actions are planned as Precautionary Urgent protective Actions (PUA), Urgent Protective Actions (UPA) and Early Protective Actions (EPA). These include sheltering, administration of prophylactics, control on consumption of contaminated foodstuff and evacuation. It is essential to ensure that the response measures would reduce the overall impact on public to a level significantly lower than what it would be in the absence of such measures, it is ensured that implementation of protective actions will do more good than harm. The EPR plan gives details of the protective measures, generic criteria and operational criteria approved by AERB for initiating protective measures to limit radiation exposures.

Evacuation is an extreme measure taken after evaluating the risks and benefits of the protective action in terms of the projected/received dose. If the projected dose in the affected zone continue to exist beyond reference levels, then relocating the affected population is resorted to.

The generic criteria (projected dose) greater than 100 mSv/y is used for justified protective actions and 20-100 mSv/y is used for optimization of protective actions in addition to other generic criteria specified in revised AERB/SG/EP-2 (draft) and AERB/SG/EP-5(2014). The reference level in terms of residual dose of 20 mSv/y is used for termination of emergency.

vi. Contamination Control

The contamination control measures include segregation of contaminated persons and decontaminating them, decontamination of vehicles, regulating the traffic, access control to prevent unauthorized entry to affected zone, confiscation of contaminated food stuff and supplying fresh food, banning fishing in contaminated sea/river water, banning the consumption of contaminated water and supplying fresh water, identification of contaminated areas requiring excavation and disposal of contaminated soil, decontamination of contaminated dwellings and destroying the contaminated crops and grass.

16.3.2 Assistance to Affected Personnel

In the event of an emergency, the plant management is responsible for providing all necessary assistance for protective measures to the affected plant and site personnel in respect of their treatment, sheltering and evacuation as necessary. The responsibility for providing assistance to persons in the public domain rests with the district authority and state government

i. First-aid

Each NPP site has at least one fully equipped first aid centre manned round the clock by trained personnel for providing first aid to the injured/contaminated persons. This is located as close as possible to the personnel decontamination centre.

ii. Decontamination

Monitoring the contamination and carrying out decontamination of personnel, equipment, facilities and areas within plant and site is the responsibility of the plant management. It is also responsible for setting up fixed and mobile facilities for carrying out decontamination with adequate supply of water. While it is the responsibility of the district authorities to set up such facilities in the public domain, the actual operations are carried out by incident response team under the guidance of the plant management.

iii. Transportation

All necessary resources for transport are mobilized within the plant in the shortest possible time in case of a site emergency to undertake evacuation of non-essential staff. This is done under the supervision of plant management. Adequate stock of diesel oil and petrol is maintained at the NPP at all times to face such an eventuality. Organizing the transport for evacuees in the affected sectors in the public domain is the responsibility of OED. The district authorities are empowered to mobilize even private vehicles, if found necessary.

iv. Medical Treatment

The injured and affected site personnel will be treated as necessary in radiation emergency treatment wards in the hospital managed by site. These wards are equipped with necessary instruments, medicines, operating theatres, beds, decontamination centres etc. and are operational at all times.

The responsibility for treatment of affected persons in the public domain rests with the District Health Authority. However, any guidance needed in the treatment of radiation injuries will be provided by experts of the medical division of the NPP and the Department of Atomic Energy.

16.4 REGULATORY REVIEW AND CONTROL

Appropriate laws, regulations and requirements regarding emergency preparedness as applicable to NPPs are in place and are being complied by NPPs. Adequate regulatory control is exercised by AERB through regulations, review/approval of EPR plans of the NPPs and taking part in the emergency exercises. The EPR plans are updated and maintained taking into account the change in regulation, experience gained, population, demographic conditions and infrastructure in the emergency planning zone. The implementation of emergency plans has to be demonstrated before criticality of the unit. For multi-unit site the plant / site / offsite emergency plans are revised before issuing construction consent to a new facility.

Periodic Off-site emergency exercises are carried out as per the regulatory requirements and are witnessed by AERB observers to ensure that the emergency planning is adequate and its implementation is effective. The periodic regulatory inspections of the NPPs are carried out to ensure the following:

i. Availability of the updated emergency preparedness plans;
ii. Availability of various communication facilities and their periodic testing;
iii. Inventory of equipment at the emergency control centres and their maintenance;
iv. Availability of trained manpower for emergency actions;
v. Availability and maintenance of support facilities like firefighting equipment, ambulance, first-aid, decontamination, and off-site storage of prophylactics, arrangements for medical management of exposed personnel and other resources.
vi. Rectification of deficiencies observed during previous emergency exercises and regulatory inspections.

The AERB has established the system for tracking the status of and decisions related to recommendations and actions on EPR arising from reviews and exercises.

16.5 REVIEW AND REVISION OF REGULATORY REQUIREMENTS ON EPR

Subsequent to Fukushima accident, AERB made re-assessment of the current EPR plans, regulatory documents for EPR, infrastructure to support EPR actions etc. Mock exercises were conducted at all the NPPs with representatives from NDMA, CMG, AERB and NDRF with public involvement (Fig. 16.1). Areas for improvements with respect to EPR were identified. The actions resulting from this re-assessment are as follows:

16.5.1 Revision of regulatory documents on EPR

AERB reviewed the requirements prescribed in the AERB safety documents for emergency preparedness and response. AERB revised emergency preparedness and response (EPR) requirements and prepared safety Guidelines (draft) “Preparation of Off-Site Emergency Preparedness and response Plans for Nuclear emergency” (Revised AERB/SG/EP-2, (draft)). This provides requirements and guidance for establishment of off-site emergency preparedness and response plan for nuclear emergency. These safety guidelines provide requirements for emergency preparedness and response. The requirements have been provided for implementation of protective actions on the basis of generic criteria, operational criteria and reference levels. These revised AERB safety guidelines are in line with GSR-Part-7 (2015) (see Article 16.2.7). The generic criteria greater than 100mSv/y is used for justified protective actions and 20-100 mSv/y is used for optimization of protective actions. This document takes into account NDMA guidelines, AERB Safety Guideline AERB/NRF/SG/EP-5, (Rev. 1) “Criterion for Planning, Preparedness and Response for Nuclear or Radiological Emergency”, Implementation of Decision Support System (DSS) at NPPs and establishment of On-Site Emergency Support Centre at NPPs.

Regulatory Requirements for Multi-Unit Site

The EPR arrangements for multiunit sites were reviewed and considered in the revised regulatory documents to strengthen EPR arrangements. This includes consideration of simultaneous events at multi-unit NPP sites, combinations of hazards, extensive infrastructural damage that can impact on-site and off-site emergency plans and longer duration emergency situations.

16.5.2 Enhancement of infrastructure for Emergency Preparedness & Response

To strengthen EPR, the enhancement of the infrastructure such as given below has been done.

i. On-Site Emergency Support Centre at NPPs

A centralized On-Site Emergency Support Centre common to all NPPs at a site is envisaged to be constructed within the exclusion zone. This facility is designed 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. From this facility all actions required for controlling the plant parameters for accident management will be coordinated. The centre will be self-sufficient with following features:

- Resting provisions for about sixty persons equipped with food and drinking water facilities for seven days
- Availability of selected plant data from all NPPs at the site including onsite/offsite radiological data.
- Infrastructure such as diverse communication means, dedicated air cooled diesel generators, dedicated survival ventilation system, first aid facilities etc.
- Radiological monitoring & protective equipment (dose monitoring devices, sufficient number of protective clothing etc.)
- Seismically and environmentally qualified site emergency support centres.

AERB had mandated the requirement for establishing the On-Site Emergency Support Centre (OESC) at all NPP sites. As design guidelines for such a centre were not available, structural design of the building and detailing of systems and facilities had to be evolved and later finalized by NPCIL in consultation with and concurrence of AERB. The design of OESC has been finalized by the utility. AERB has reviewed and accepted this design for implementation which is in progress.

ii. Decision Support System

Decision Support System (DSS) for nuclear emergencies is intended to provide comprehensive and timely information to emergency managers on an emergency situation arising from a nuclear accident. Based on the readings of installed radiation monitors and meteorological conditions, the DSS estimates the projected public dose. These estimates are used to decide appropriate protective actions in the public domain. Two DSS systems developed indigenously are operational on experimental basis at MAPS and NAPS.

The GIS based 'ONERS' system is fully functional at MAPS, Kalpakkam site with online linking of meteorological and environmental radiation monitoring data. This system is completely indigenous with collaborative team efforts. The system was used during the site and Off-site emergency exercises. The system features include (a) A weather forecast model to predict the dynamical meteorological conditions (winds, rainfall, stability etc.) in 100-km range around the site to predict plume condition (b) Real-time meteorological observations from MET towers linked by RF communication to estimate the radionuclide dispersion (c) Network of Environmental Radiation Monitors (ERM) with transmission of data by RF / LAN for radiation surveillance & input for source-term calculation (d) A source-term model for calculation of release rates during accident scenario using real-time ERM & MET data (e) Long & short-range atmospheric dispersion/ dose assessment models to calculate concentration, deposition and radiation dose profiles using MET predictions and source term inputs (f) Spatial data base of the site region (Villages, Transport network etc.) and non-spatial (population etc.) in digital GIS format for projection of accident severity (g) A Geographical Information System with query and analysis tools to integrate and analyze the outputs of dispersion models with spatial data for impact assessment, protective measure support, and guidance for mitigation during nuclear emergency.

iii. Nuclear and Radiological Emergency Monitoring Cell

During nuclear and radiological emergency situation, it is essential for AERB to obtain up to date information about the emergency situation in the NPP, radiological safety of the emergency plant workers, public and the environment in a more formal and continuous basis.

To facilitate this Nuclear and Radiological Emergency Monitoring Cell (NREMC) is established at AERB. This is in addition to the two other Emergency Communication Rooms which function on a 24x7 basis as mentioned in Article 16.2.5.4(c). The NREMC has the required infrastructure and communication facilities, documents and protocols to obtain the information during emergency conditions. In addition AERB has prepared action plan to get prompt and accurate information on the emergency situation at the affected plant to perform its intended emergency response functions effectively. Recently, AERB has started the practice of activating the NREMC during the site and off-site emergency exercises conducted at various plants to test its mechanism for obtaining information for assessing the situation. During the recent KAPS incident, station was providing the prompt information on emergency situation in addition to the periodic reports from the licensee/plant authority. This information was used for assessment of emergency situation and mitigation measures taken at site.

NREMC consists of experts to review and assess the emergency situation and also to collect important information including radiation status of the plant, site and off-site. Based on the available information and assessment, the NREMC will oversee and review the emergency management action/ mitigation measures performed by various responsible agencies.

AERB has recently formed a dedicated group for handling functions related to emergency preparedness. The group's mandate includes to update the AERB's internal procedures, carrying out regulatory inspections at NPPs with respect to Emergency Preparedness, deputing regulatory observers during Site and Off-site Emergency Exercises, reviewing EPR plans (plant, site and off-site) of NPPs, developing the regulatory documents on EPR and participating in National and International forums related to EPR.

iv. Capacity Building Measures

The National Disaster Response Force (NDRF) has been established and trained in response actions for nuclear and radiation emergency. This force is equipped with instruments and equipment for emergency response.

16.6 INFORMATION TO PUBLIC AND NEIGHBOURING COUNTRIES

16.6.1 Information to Public

Regular training courses are arranged by each NPP for the general public in the surrounding areas by inviting them to the plant. The course contents include an introduction to atomic energy, safety in nuclear industry and about emergency response plan in that nuclear power plant. As a part of this public awareness programme, visits to the Emergency Control Centre and the Environmental Survey Laboratory are also arranged. As a means of creating better public awareness on this subject, a short list of 'do's and don'ts' during an emergency is distributed to the general public.

During an emergency, the protective measures would be communicated to the public through mass media communication and local communication system such as megaphone etc. The communication to the public is implemented through the local and district authorities. A pre-designated Information Officer makes arrangements for the reception of media and information briefing.

16.6.2 Transboundary Implications

The neighbouring countries are at large distances from the location of operating NPPs and projects under construction. Although no trans boundary implications are expected, India being a contracting party to 'Convention on early notification of a nuclear accident' and 'Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency CMG-DAE will notify to IAEA in case of any accident at Indian NPP. Export of food items will be subjected to thorough contamination checks and clearance in accordance with the international guidelines.

16.7 PARTICIPATION IN IAEA EMERGENCY EXERCISES

India is signatory under the Convention on Early Notification of Nuclear Accidents and Convention on Assistance in case of Nuclear Accident or Radiological Emergency. Under these Conventions India actively participates in the Emergency exercises through CMG-DAE, the national contact point. In the last three years (April 2013 to March 2016), India participated in ConvEx exercises which includes ConvEx-2a (4 no's), ConvEx-2b (3 no's), ConvEx-2c (1 no), ConvEx-3 (1 no) and ConvEx-1 exercises.

16.8 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

Appropriate laws, regulations and requirements regarding emergency preparedness and response as applicable to NPPs are in place and are being implemented by the utility. The relevant regulatory requirements and guidance have been updated taking account of the international practices and IAEA documents. Adequate regulatory control is exercised by AERB, through regulations, regulatory inspections, approval of emergency response plans of the utilities and taking part in the emergency exercises. Therefore, India complies with the obligations of the Article 16 of the Convention.

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ARTICLE 17: SITING

Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented:

- **i. for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime;**
- **ii. for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;**
- **iii. for re-evaluating as necessary all relevant factors referred to in sub-paragraphs (i) and (ii) so as to ensure the continued safety acceptability of the nuclear installation;**
- **iv. for consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation and, upon request providing the necessary information to such Contracting Parties, in order to enable them to evaluate and make their own assessment of the likely safety impact on their territory of the nuclear installation.**

17.0 GENERAL

In India, only the Central Government or a company established by the Central Government are permitted to set up NPPs as per the present statutory provisions. The Government of India constitutes Standing Site Selection Committee (SSSC) which carries out first order assessment of the site and evaluates the suitability of the various sites proposed by concerned state governments taking into account various site related factors. Ready acceptance criteria, in terms of Screening Distance Value (SDV) of site from potential sources of external events which could jeopardize safety and for which no engineering solutions are available, are applied at site selection stage to shortlist the candidate sites. Based on the recommendation of the SSSC, the Central Government conveys in principle approval of the site.

Setting up of NPPs requires environmental clearance from Ministry of Environment, Forests and Climate Change (MoEFCC), as per the requirement of Environmental Protection Act 1986, other clearances from various Central and State level agencies like National Airport Authority, State Maritime Boards, Ministry of Defence and Ministry of External Affairs, as appropriate besides the agencies mentioned in chapter on Article-7.

Utility is also required to obtain siting consent from AERB. The regulatory consent for siting involves review of the various site and plant related safety aspects. The mechanism of review is brought out in chapter on Article-14 on ‘Assessment and Verification of Safety’. AERB Safety Code on site evaluation of nuclear facilities, AERB/NF/SC/S, Rev. 1, 2014, establishes the requirements for evaluation of a site from safety considerations. Some of the salient features of AERB/NF/SC/S (Rev. 1) with respect to the lessons learnt from Fukushima and the mandate of Vienna Declaration on Nuclear Safety include: revised dose criteria, considerations for exceedance of design basis, consideration for evolution of hazard with time, considerations for multi-unit/multi-facility sites, periodic re-evaluation of hazards, requirements regarding ultimate heat sink and requirements related to monitoring of hazards.

A site is considered acceptable, when all the site related issues have been satisfactorily resolved, thus giving assurance that the proposed NPP can be engineered, built and operated such that the risk to the public and the environment is within acceptable limits.

17.1 EVALUATION OF SITE RELATED FACTORS AFFECTING SAFETY

The basic factors that govern site evaluation of nuclear installation are:

i. Effects of external events on the installation.

ii. Effects of the installation on site environment and population.
iii. Factors affecting implementation of emergency measures in public domain.

Utility prepares a site evaluation report covering the above aspects including brief design information of the proposed project and overview of the proposed NPP. The information helps in evaluating the given site in relation to the type, capacity, number of units etc. It also includes overall safety approach, dose limits, bases for emergency preparedness and offsite power supplies.

The regulatory review and assessment of Site Evaluation Report is carried out to determine the potential consequences of interaction between the plant and the site and the suitability of the site for the proposed plant from the point of view of safety. It also includes assessment of population data, availability of roads & access features for emergency response purposes and aspects on security measures with reference to site characteristics.

The effect of various site parameters on engineerability of the site in the context of external and human induced events is assessed.

17.1.1 Characterization of effect of site on plant

A site is evaluated for phenomena or combination of phenomena, which have annual frequency of more than 10^{-7} per year. The foreseeable evolution of these events and their combinations related to the region, along with population growth and distribution that may have a bearing on safety and radiological impact are monitored, evaluated and periodically reviewed for a time period encompassing lifetime of the facility.

Requirements for design provisions against internal and external events are governed by the AERB safety code for design of nuclear power plants. Design bases are established both for natural and human induced external events. The design parameters for external events are derived by systematic assessment of hazard associated with the events, taking into consideration site-specific conditions and the data / information collected. Uncertainty analysis is also performed as part of the evaluation of the hazard. For an external event (or combination of events) the choice of values of the parameters upon which the plant design is based should ensure that structures, systems and components important to safety in relation to that event (or combination of events) will maintain their integrity and will not suffer loss of function during or after the design basis event.Robust design of the plant ensures that it possess sufficient safety margin to protect against site specific external natural events (earthquake, flood, extreme wind, and temperature) beyond the design basis and to avoid cliff edge effects. Design provisions against external and internal events are detailed in Chapter 18.

The facilities are graded based on their hazard potential into four categories. For each category the mean annual frequency of exceedance for external natural events are specified.

Changes of hazard (both natural and human induced) with time over the lifetime of the facility is also postulated in evaluating design basis parameters for external events. The assessment takes into account the changes due to regional climate change associated with global climate change and change in physical geography of drainage basin, offshore bathymetry, coastal profile, catchment area, etc. An example of this consideration is the enhancement of precipitation corresponding to design basis level, which was done for one of new sites.

17.1.1.1 Site investigations

Natural phenomena, which may exist or can occur in the region of a proposed site are identified and classified as per their impact on plant safety. Design bases are derived for each credible event and credible combination of events by adopting appropriate methodologies. Historical records of the occurrences and severity of the natural phenomena are collected for the region. The data is analysed for reliability, accuracy and completeness. If data for a particular type of natural phenomenon are incomplete for the region, then data from other regions having similar characteristics are used for evaluation of the design basis event, with proper justification and conservatism.

Hazards due to earthquake induced ground motion are assessed for the site considering site seismicity and seismotectonics of the region along with specific site conditions. Data from geological, geophysical, seismological and geotechnical investigations are collected and analyzed. Information on all earthquakes including pre-historical, historical and instrumentally recorded earthquakes in the region 300 km around the site are collected, documented and considered. All seismically active structures and active faults in the region shall be identified. On the basis of geological, geophysical, geodetic or seismological data, a fault is classified as active or not active. If it cannot be established that a fault is not active, the same shall be considered as active in the seismotectonic evaluation.Geological and seismological investigations are conducted in four scales, regional (300km minimum), intermediate range (50km radius), local (5km radius) and site area (within plant boundary). Each set of study leads to progressively more detailed investigation resulting in large volume of data and information as it gets closer to site. No NPP is located in seismic zone-V defined as per national standard IS 1893. If there is an evidence of a capable fault within a distance of 5 km from the reactor center, the site is deemed unacceptable. Micro-seismic measurements of the site region are conducted for at least 3 years after the site is selected for the purpose of site evaluation and are continued for an operating NPP.

Potentials for slope instability (land/rock slides), land erosion, collapse, subsidence or uplift of the site surface are assessed. Subsurface investigations are carried out to establish competency of the foundation medium. The ground water regime and its chemical properties are also studied. Liquefaction potential at the site is evaluated for the design basis vibratory ground motion with margins to account for extreme events.

Meteorological and climatological characteristics of site region are investigated to derive design basis parameters for the meteorological variables such as wind, precipitation, temperature, storm surges. Potential missile hazard associated with tropical cyclones is also considered.

The site is assessed for flooding potential due to natural causes such as run-off from precipitation, high tide, storm surge or from earthquake induced water waves (tsunamis and seiches). Floods and waves caused by failure of upstream dams/barrages or due to possibility of temporary blockage of rivers upstream/downstream caused by landslides are also assessed with respect to the safety of the installation.

For coastal sites, studies are carried out to establish that there is no potential for shore instability that could affect safety. For inland sites, possible erosion of river banks and/or change of river course are given due consideration.

With regard to human induced external events, the site and surrounding region are examined for facilities and human activities that may affect the safety of the proposed nuclear facility. Information concerning the frequency and severity of important human-induced events are analysed.

The region is investigated for potential hazard due to aircraft crash, chemical explosion/toxic gas release in industrial facilities, or any other hazards that may result from industrial / radiation / nuclear facilities located away from site as well as within the site boundary. When probabilistic hazard assessment methodology is adopted, the design basis parameters due to external human induced events is derived for an annual frequency of 10^{-4} for category-I facilities.

As an illustration, some of the salient features considered by AERB during site evaluation for 4x700 MWe PHWRs at Gorakhpur, Haryana (GHAVP), are given in Annexure 17-1.

Table - 4 : Rejection and mandatory criteria in site evaluation

	Hazard	Criteria
Direct rejection	Earthquake	Site in seismic Zone-V as per National std IS 1893
	Earthquake	Existence of capable fault within 5 km of site
Rejection: In absence of reliable engineering solutions	Earthquake	Potential for soil liquefaction
	Earthquake/geological	Potential for slope instability
	Earthquake/geological	Potential for ground collapse/subsidence/uplift
	Geological	Formation of sand dunes
	Geological	Volcanoes

17.1.1.2 Assessment of site characteristics for projected operating period

Site characteristics and characteristics of natural environment in the site region which may affect safety of the nuclear installation are investigated and assessed rigorously at the site evaluation stage for a projected time period encompassing the lifetime of the installation. Monitoring and investigation of site characteristics and natural environment is continued during the operating life as a part of periodic safety review. Effects of the combination of these hazards with ambient hydrological, hydro-geological and meteorological conditions as well as the relevant plant internal events is given due consideration while deriving their design basis values.

17.1.2 Regulatory Review and Control

AERB requires that site evaluation report should be submitted for siting consent. AERB safety guide AERB/NPP-RR/SG/G-1:2007 on “Consenting Process for Nuclear Power Plant and Research Reactor” gives the guidelines on the contents of the site evaluation report. The significant areas of review and assessment as per this AERB safety guide are as follows:

i. Geology and soil mechanics

ii. Topography

iii. Hydrology and hydro-geology

iv. Meteorology

v. Natural phenomena such as earthquakes, floods, tsunamis and tornadoes

vi. Potential external man-induced events such as plane crashes, fires and explosions

vii. Failure of man-made structures such as dams and sea walls

viii. Availability of water for plant cooling and ultimate heat sink

ix. Reliability of off-site electrical power

Regulatory review of application for siting consent is carried out through multi-tier review system of AERB (section 14.1.1.2 (ii)). Staff of AERB carries out regulatory inspections during siting stage and its findings are referred during the review of the application for siting consent.

The site is reviewed and assessed to determine the potential consequences of interaction between the plant and the site and the suitability of the site for the proposed plant from the point of view of safety. In general the site assessment criteria is divided into three: rejection criteria, which deals with the issues which if observed at site calls for direct rejection of site; mandatory criteria, which requires existence of engineering solutions for the observed issues; and ready acceptance criteria, which are based on screening distance values. Table – 4 lists the issues that constitute the rejection and mandatory criteria. During site evaluation, focus is specifically on ruling out the existence of issues related to rejection criteria, and ensuring availability of engineering solutions for issues related to mandatory criteria.

The siting consent is issued for a limited period. During subsequent stages of construction, the status report on compliance with AERB's stipulations if any, made during the earlier stages is required to be submitted to AERB.

17.2 ASSESSMENT OF IMPACT OF NPP ON PUBLIC AND THE ENVIRONMENT

Assessment of the impact of NPP on public and the environment is carried out in compliance with the acts and rules described in Chapter – 7.Siting consent by AERB and siting clearance from Ministry of Environment, Forests and Climate Change (MoEFCC) are given after detailed assessment of the impact of NPP on the environment.

17.2.1 Assessment of environmental impact by MoEFCC

Environmental clearance from the Ministry of Environment, Forests and Climate Change (MoEFCC)is a precondition for issue of siting consent by AERB. For obtaining environmental clearance from MoEFCC, Environment Impact Assessment (EIA) Report in a prescribed format is prepared by the utility. The Expert Appraisal Committee (EAC) constituted by MoEFCC carries out a preliminary review of the EIA report and determines the terms of reference on the basis of the information furnished, site visit if needed and other information that may be available with it. Based on the evolved terms of reference, the utility has to revise the report addressing all the concerns raised by the EAC.

Public Consultation is an essential pre-requisite for obtaining MoEFCC clearance in the formulation of a project. This process has two components (i) a public hearing at the site or in its close proximity to be carried out in the prescribed manner and (ii) obtaining response in writing from other concerned persons having a plausible stake in the environmental aspects of the project. Public hearing is conducted as per the 'procedure for conduct of public hearing' given in the gazette notification from MoEFCC. After completion of the public consultation, the project proponent addresses the environmental concerns expressed during this process and makes appropriate changes in the draft EIA and Environment Management Plans.

The EAC carries out the detailed scrutiny of the application and other documents like the final EIA report, outcome of the public consultations including public hearing proceedings, submitted by the applicant to MoEFCC for grant of environmental clearance. This appraisal is made by the EAC in a transparent manner at a proceeding to which the applicant is invited for furnishing necessary clarifications. On conclusion of this proceeding, the EAC makes recommendations to MoEFCC for grant of prior environmental clearance on stipulated terms and conditions, or rejection of the application, together with reasons for the same.

17.2.2 Safety Assessment by AERB

The Atomic Energy (Radiation Protection) Rules, 2004 stipulates that, the licensee shall ensure compliance with the dose limits, safe disposal of radioactive waste and other regulatory constraints specified by the competent authority by order under these rules.

Further, according to AERB Safety Code on Site Evaluation of Nuclear Facilities (AERB/NF/SC/S, R1), potential radiological exposure to public during operational states and accident conditions shall be assessed during the life cycle of the facility. It also requires that site specific parameters be used for a realistic estimation of the doses. Moreover, the direct and indirect pathways by which the public might receive the radiation exposure due to radioactive materials released from the nuclear facility shall be identified and used in the estimation of the radiological impact. The Code also specifies the dose criteria for normal operation and accident conditions (refer Table -5).

Table - 5 : Dose Criteria

Condition	Dose limit	Remarks
Normal Operation	Annual release limit from site <1.0 mSv/year	Sufficient dose reserve shall be ensured
Accident conditions:		
1. Design Basis Accident (DBA) (Initiating event with consequential failure and taking credit of safety systems considering single failure criteria)	Design target for effective dose < 20.0 mSv/ year	No need for offsite countermeasures (i.e. prophylaxis, food control, shelter or evacuation) involving public, beyond exclusion zone.
2. Design Extension Condition (DEC) without core melt (multiple failure situations and rare external events)	Design target for effective dose (Same as DBA)	• No necessity of protective measures in terms of sheltering or evacuation for people living beyond Exclusion Zone. • Required control on agriculture or food banning to be limited to a small area and to one crop
3. Design Extension Condition with core melt (Severe Accident)	--	• No permanent relocation of population. • The need for offsite interventions to be limited in area and time

For each proposed site the potential radiological impact on people in the region during operational states and accident conditions is assessed. Base line data required for assessment of radiological impact is collected for various environmental components, viz., air, water, land and biological etc. These include physio-chemical, biological characteristics & activity of ground water and surface water, soil characteristics, composition of vegetation cover, meteorological parameters etc. which are described below:

(a) Meteorological data:

A program of meteorological measurements is initiated at the site before start of construction of NPP and continues till its decommissioning. Based on the requirements of AERB/NF/SC/S, meteorological data is collected for a minimum period of one year and examined during site evaluation. This includes

- Assessment of inversion conditions,
- Atmospheric stability,
- Humidity,
- Rainfall and
- Hourly data for wind speeds, wind directions and calms.

In case of sites situated in river valleys, bowls and uneven topography, additional data is generated and appropriate model is used to assess the dilution factor, if found necessary. If sufficient site-specific data is not available, data from a region with similar characteristics is used for initial assessment, with appropriate justification.

(b) Hydrological data:

The hydrological characteristics of the region include:

- Location, size, shape and time variations of mass flow and velocity for rivers, current for lakes and seas and silt and other loads for all water bodies.
- Major upstream and downstream water control structures and their design features.
- Location of water intake points and quantum for domestic, irrigation and industrial purposes.
- Thermal stratification in lakes.
- Tidal influence

In case of inland sites, site specific data generated includes dispersion characteristics of water bodies, pick-up of radioactivity by sediment and biota, transfer mechanisms of radionuclides in hydrosphere and identification of exposure pathways for the significant radionuclides.

(c) Hydrogeological data:

A description of the hydrogeology of the region is developed including:

- Description of saturated and unsaturated zones.
- Water table contours and their variations
- Direction of ground water movement and its velocity.
- The recharge and withdrawal rate of ground water and its use along with any interaction with surface water.
- Nature of aquifer (local/regional).
- Connection of aquifer with other regional water bodies

Hydrogeological investigations of the site is carried out to evaluate the impact of ground water contamination on population. These investigations include:

- Porosity, physico-chemical properties, migration and retention characteristics of soil.
- Dispersion characteristics of the underground water bodies.
- Retention characteristics of the underground strata.
- Data on existing and projected use of water from ground aquifers.
- Pathways of radionuclides leading to population exposure through ground water

(d) Demographic and land use data

Information on population distribution (existing and projected), including permanent residents, transient and seasonal population are collected up to a radius of 30 km and updated during each periodic safety review during the life time of the nuclear plant. The uses of land and water is characterised in order to assess the radiological impact of the nuclear facility on the region and also for the purpose of preparing emergency plans. The investigation covers land and water bodies up to a distance of 30 km that are used by the population or may serve as a habitat for organisms in the food chain.

Effects of the plant on the environment that could warrant specific design or operational requirements are radioactive effluents (liquid and gaseous), radiation exposure of the public from these effluents and other environmental pollutants. This is assessed for normal operation, anticipated operational occurrences and accident conditions, taking into account dispersion patterns, present and prospective population distribution, public water supply, milk and food consumption, and radioecology. As per the requirements of AERB/NF/SC/S, RIA for dose evaluation considers all radiation exposure pathways including inhalation and ingestion routes. Dose criteria is given in Table -5.

The requirements and the criteria with respect to radiation protection and emergency measures are implemented as follows:

a) An exclusion zone is established around the plant, as specified by AERB and this area is kept under the exclusive control of the Plant Management. The public habitation in this area is prohibited. Further, a natural growth zone around the exclusion zone is established and influx of population to this zone is controlled by administrative measures
b) An emergency planning zone (EPZ) of 16 km radial distance (from reactor center) around an NPP is established for the emergency management purpose. In order to establish the baseline radiological and environmental data and for the purpose of continuous environmental surveillance, a zone of 30 km radius around the NPP is designated as radiological surveillance zone (RSZ). The site is required to have good atmospheric dispersion characteristics. Information on the population distribution, land and water use, dietary habits, critical exposure pathways is collected and an appropriate radiological model is established for assessment of dose to members of public in EPZ and RSZ.

17.2.3 Monitoring of characteristics that affect RIA

Data collected by various national institutes and accredited agencies using state of the art technology are used for monitoring and assessment by the utility. This monitoring commences at least three years before commissioning of the first facility and continues till decommissioning. The Environmental Survey Laboratory is established at every NPP site much before commencement of operation, for conducting the pre-operational studies and continued meteorological surveillance.

17.3 RE-EVALUATION OF SITE RELATED FACTORS

The estimates of design basis parameters of the plant corresponding to external events could change due to advancement of state of the art knowledge used for estimation of parameters, occurrence of natural events exceeding the scenarios considered, revision of regulatory requirements, etc. AERB safety Code, AERB/NF/SC/S requires that site characteristics shall be re-evaluated in case of the following:

a) Revision in safety regulation.
b) Occurrence of any external event/meteorological phenomena resulting in corresponding design parameters potentially higher than the ones considered originally.
c) Any deviation from the approved type/capacity of facility, and/or when more nuclear facilities are added.
d) Any expansion of activities around the site in the future that may have an impact on safety of the facilities at the site.
e) Additional data and/or new information on relevant climatic change, that may necessitate revision of design basis parameter.

Safety assessments of TAPS 1&2, RAPS 1&2 and MAPS 1&2 were carried out to re-visit the aspects related to external events like earthquake and flood due to upward revision of the design basis parameters and additional measures as found necessary were incorporated. Currently similar assessments for seismic re-evaluation are under progress for KAPS – 1&2 and NAPS – 1&2.

Immediately after the Fukushima (Japan) Accident safety re-assessment of all Indian NPPs was carried out by NPCIL and also by AERB. These assessments brought out the requirements for further enhancement in safety, especially against severe external events. The approach adopted for these safety enhancements was covered in AERB report of 6th review meeting of CNS in 2013. AERB also reviewed the existing safety documents to identify the lessons learned from the accident, which are not adequately covered by the existing documents and therefore may need to be considered during revision. All lessons are documented for use during scheduled revision of relevant regulatory documents.

Subsequently, two regulatory requirement documents, Safety Codes, one on site evaluation and other on design of LWR based NPPs has been issued/revised.

17.3.1 Regulatory oversight of site re-evaluation

Review and re-evaluation of site related factors in the light of new knowledge from operating experience feedback, a major accident or the occurrence of extreme events is a continuing process in the Indian regulatory system.

The regulatory system in India has adopted the Periodic Safety Review (PSR), which incorporates addressing the cumulative effects of ageing and comparison with the current safety requirements / practices, to identify the need for safety enhancements in the existing NPPs. At the time of the Periodic Safety Review (PSR), the following elements are comprehensively reviewed to determine the continued acceptability of the site safety status of nuclear installation:

- Changes in use of land areas around the site and population in the surroundings
- Site characteristics, particularly flood and seismic and other human activities, which may pose a hazard, and
- Local meteorological conditions

The regulatory system also incorporates a system of 'special safety reviews', undertaken following major events / developments, wherein the implications of such experience and lessons are reviewed for identifying and implementing safety enhancements. Indian NPPs have undergone many such reviews, which have resulted in enhancements in the safety features and regulatory requirements.

17.4 CONSULTATION WITH OTHER CONTRACTING PARTIES

As per the Indian regulation, the planning for emergency preparedness is carried out for the Emergency Planning Zone (EPZ), which is designated up to a radial distance of 16 km from the NPP. The populations in this zone are kept informed on emergency planning and response. The neighbouring countries are at very large distances from the location of operating NPPs and those under construction. Hence there are no trans-boundary implications. India is party to Convention on Early Notification of a Nuclear Accident (1986), and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (1986) and complies with the obligations under these conventions.

17.5 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

The Site Selection for locating an NPP is carried out by the Central Government. The utility carries out detailed site investigations and prepares Site Evaluation Report and Environmental Impact Assessment Report for independent evaluation by AERB and MoEFCC respectively. The comprehensive review and assessment of site related factors ensure that setting up of the NPP will not cause undue risk to the public and the environment. The periodic safety review for renewal of license for operation ensures that important site related factors are periodically reviewed to determine the continued safety acceptability of the nuclear installation. As all the NPPs, operating and under construction, are located sufficiently away from the national border, formal agreement with the neighbouring countries for sharing of information has not been considered necessary. Hence, India complies with the obligations of Article 17 of the Convention.

The regulatory requirements with respect to siting and design of NPPs in India are consistent with the Vienna Declaration on Nuclear Safety.

Annex 17-1: Overview of factors considered for assessment of NPP site

A recent example (section 17.2)

Recently a site has been evaluated for setting up 4x700 MWe PHWRs at Ghorakhpur, Haryana (GHAVP). The evaluation of this site was based on the requirements of AERB Code for site evaluation of nuclear facilities (AERB/NF/SC/S) and its associated Guides along with the requirements of IAEA-NS-R3. Some of the salient features/characteristics evaluated for GHAVP site were:

General:

- Accessibility of site – by rail, road, air or port
- Availability of Construction materials, water and power for construction
- Availability of water for Plant Cooling
- Start-up power and power transmission and distribution

Safety- Related Factors:

- Foundation conditions :
    - Nature of Sub-strata – Rocky or Alluvium
    - Depth to Hard Rock, if available
    - Details of Heavy Structures built in the area
    - Proneness of the area to slope instability, surface collapse, subsidence or uplift.

- Seismo-tectonics: (Potential for surface faulting presence of capable faults and occurrence of major earthquakes in the vicinity). Detailed geophysical and geological investigations within 5km radius to rule out the existence of active fault.

- Feasibility of engineering the site against liquefaction

- External flooding :

- Meteorological conditions
    - Annual Rainfall
    - Extreme Temperature
    - Extreme Wind Speed
    - Extreme Humidity
- Grade level for plant location

Human-induced events:

- Locations of airport (Civil or Military),
- Facilities Storing or handling Inflammable, toxic, corrosive or explosive materials
- Mining activities in the vicinity
- Military installations (along with distance from site storing ammunitions etc. Within 10 km radius)

Radiological impact assessment:

- Analysis was carried out for radiological impact of operation of the plant on the environment and Population around the site.

Emergency preparedness:

- Feasibility to implement emergency preparedness plan

ARTICLE 18: DESIGN AND CONSTRUCTION

Each Contracting Party shall take the appropriate steps to ensure that:

(i) **the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defence in depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur;**

(ii) **the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis;**

(iii) **the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration of human factors and the man-machine interface.**

18.0 GENERAL

National laws, regulations and requirements for setting up a NPP are summarised in chapter on Article 7: Legislative and Regulatory Framework. AERB safety code on 'Regulation of Nuclear and Radiation Facilities' AERB/SC/G; 2000 and Safety Guide AERB/NPP&RR/SG/G-1: 2007 on Consenting Process for Nuclear Power Plant and Research Reactor identify various consenting stages. The consenting process for locating and operating NPP in India is summarised in the chapter on Article 14: Assessment and Verification of Safety.

AERB published safety codes specifying safety requirements for design of NPPs. The safety code for PHWR based NPP was revised in 2009 while that for LWR based NPPs was published in 2015. These safety codes provide mandatory requirements for design and are developed based on latest international standards including that of IAEA as well as national and international experience. Safety code contains both general requirements which are technology neutral like implementation of defense in depth, safety analysis, concept of single failure, management of safety etc. as well as specific requirements which are technology specific like systems specific requirements of shutdown system, ventilation system etc. The general requirements are utilized for review of different technology based NPPs as well. In addition to this, AERB has also used a document developed by it titled 'Safety Criteria for Design of Fast Breeder Reactors' for design review of PFBR.

AERB safety code on Quality Assurance specifies requirements for overall quality assurance programme for constituent phases, viz. design, manufacturing, construction, commissioning, operation and decommissioning of NPPs. The details on the utility's safety management system for ensuring quality requirements during design, fabrication, construction etc. are brought out in chapter on Article 13: Quality Assurance.

18.1 IMPLEMENTATION OF DEFENCE IN DEPTH

The application of concept of defense in depth in design of NPPs is one of the requirements of AERB and has been specified in its design safety codes.

The concept is implemented in the reactor design by means of five structured levels of protection which act in succession. In case of failure of one level the subsequent level comes into action. Each level is provided with a set of systems or design features to ensure prevention of degradation, its detection & control and mitigation, if prevention fails.

Implementation of defence in depth philosophy requires that the design of SSCs of NPP is conservative with sufficient margins and their construction is of high quality to prevent deviation from normal operation and failure of items important to safety. Design includes equipment to identify and take control of any routine operational disturbances including possible human errors during operation to detect and control deviations from normal operation states to prevent accidental operational occurrences from escalating to accident conditions.

These two levels together render operation of plant safe. Postulating that there could be variety of possible failures (PIEs) in the normal operating systems, third level of defence ensures the plant remains in safe state by activating specific safety systems. This level includes provision of multiple safety systems supplementing the normal operational features of the plant so that the effect of any such failure is mitigated within the plant. The general principles implemented in design of these safety systems are ‘conservatism’, ‘independence’, ‘redundancy’, ‘diversity, ‘physical separation’ and, as far as possible, ‘fail-safe’. Multiple failures beyond design basis render the plant into design extension condition (DEC). The fourth level of defence is for mitigating consequences of multiple failures by incorporating provisions for additional safety systems and complementary safety features in the design. These systems/features further extends safety by mitigating consequences of accidents without core melt and accidents with core melt so that the radioactivity released to environment remains within limits and meets the acceptance criteria.

The probability of severe accident that may lead to large radioactive releases becomes very low after implementing all the aforementioned levels of defence. The fifth level of defence is for mitigating the radiological consequences of an accident and it is implemented through off-site emergency preparedness.

Following principles are adopted to ensure that structures, systems and components having bearing on nuclear safety are designed to meet stringent performance and reliability requirements,

i. The quality requirements for design, fabrication, construction and inspection of these systems are of high order, commensurate with their importance to safety.

ii. The safety related equipment inside the containment building are designed to perform the desired function under the environment conditions expected in the event of postulated design basis accident.

iii. Physical and functional separation is ensured between process systems and safety systems to the extent practicable. This separation is also provided between different safety systems and between redundant components of a safety system. These features ensure that a single local event viz. fire, missile, pipe failure, will not result in multiple component/system failures and the functions required for safety of the reactor are not impaired due to common cause failures.

iv. Adequate redundancy is provided in the system such that the minimum safety function can be performed even in the event of failure of single active component in the system. In addition to meet ‘single failure criteria’ requirement, safety systems are also required to achieve specified unavailability targets, evaluation of which takes into account permissible down time of the equipment specified in the ‘Technical Specifications for Operation’. Each channel in Reactor Control & Protection Systems is independent of other channels, with separate detectors, power supplies, amplifiers and relays. This arrangement ensures that safety function will be performed reliably by allowing testing and maintenance of a control or protection channel without affecting reactor operation.

v. To minimize the probability of unsafe failures, wherever possible, the logics and instrumentation circuits are designed such that in case they fail, they fail in the safe direction.

vi. Provisions are incorporated in the design to ensure that active components in safety systems are testable.

vii. All support systems viz. electrical power supply, pneumatic power supply & cooling water supply, necessary for the satisfactory functioning of the safety systems are from reliable sources such that single component failure does not jeopardize the minimum supply requirements.

viii. Comprehensive deterministic safety analyses and probabilistic safety assessments throughout the design process and all stages during lifetime of the plant confirm that the design, as delivered, meets requirements for manufacturing, construction, as built, as operated and as modified.

The safety requirement of radiation dose limits for member of public due to occurrence of a ‘Design Basis Accident’ or a ‘Design Extension Condition without core melt’ has been specified in the AERB code. It is also required that design should demonstrate that in case of a Design Basis Accident, there need not be any emergency countermeasures in the public domain. In case of design extension condition without core melt limited counter measures in terms of food control may be acceptable. In case of design extension condition with core melt, design goal remains that emergency actions will be required for limited time and area. There should not be any situation which will call for permanent relocation of member of the public. This is consistent with the Vienna Declaration on Nuclear Safety.

The design of the plant also takes into consideration external events specific to a site. The external events are grouped into natural events and human-induced events. Natural events considered in the design are seismic events at the site and extreme meteorological phenomena such as heavy precipitation, floods, high winds, cyclones, tsunami etc. Human-induced events include hazards from toxic and explosive materials, blasting, aircraft impact etc. For each of the events, whose potential at the given site is known to exist, a design basis event is established. For a multi-unit/multi-facility site, consequences of external events are assessed considering their impact on all units/facilities at the site, including common cause failures. Such assessment also includes consequential effects due to incidences in one facility/unit on other facilities/units.

Two different intensities of earthquakes viz. operation basis earthquake (OBE) and safe shutdown earthquake (SSE) are considered for the seismic design of the plant. The OBE represents the intensity of earthquake for which the plant is designed to remain functional during and after the event. The SSE is that earthquake which produces the maximum vibratory ground motion, depending on the maximum earth quake potential of the site, for which certain structures, systems and components are designed to remain functional. These structures, systems and components are necessary to assure the integrity of the reactor coolant pressure boundary, the capability to shut down the reactor and maintain it in a safe shutdown condition, the capability to prevent the accident or to mitigate the consequences of accidents which could result in potential off-site exposures higher than the limits specified by the regulatory body and the capacity to remove residual heat.

Flooding in inland sites could be caused by heavy precipitation or by the release of large volumes of water due to failure of upstream dams under seismic disturbance or any other cause. The plants are designed for a design basis flood resulting from probable maximum precipitation with a mean recurrence interval of 10000 years. Flooding due to failures of upstream dam is also considered. Failures of dams located downstream may also affect availability of ultimate heat sink and are therefore considered in the design. For coastal sites, flooding due to cyclones, tsunami and wind waves are considered in the design.

A diverse and flexible accident response capability is provided in the design such that it would provide a backup to permanently installed plant equipment, that might be unavailable following certain extreme conditions (e.g. extreme natural phenomena such as earthquakes, flooding and high winds), and would supplement the equipment already available for responding to severe accidents. The approach includes design measures to provide multiple means of obtaining power and water needed to fulfil the key safety functions of maintaining core cooling, containment integrity, and spent fuel pool cooling.

Along with the above, additional safety margin are considered to ensure safety against the impact of cliff edge effect.

As a design improvement, seismic trip is implemented in all power plants where earlier it was not available. External cooling water supply provision to steam generators were already available in all existing PHWRs. In addition to it the hook up points are provided in Primary Heat Transport System, Emergency Core Cooling System, Moderator System, End Shields Cooling System and Calandria Vault Cooling System for injecting external water. Water injection provision to spent fuel storage pool of all PHWRs are provided. Important plant parameters are identified which need to be monitored during a design extension condition. External power supply scheme has been implemented to monitor important plant parameters and water injection pumps (in limited case) from standalone air cooled diesel generator as safety enhancement. Design of Containment Filtered Venting System (CFVS) is finalized and will be implemented as required. Functional testing of indigenously developed Passive Catalytic Recombiner Device (PCRD) has been completed. These will be installed in NPPs in a phased manner. Review for design of 'On-site Emergency Support Center' in all NPP sites is in progress.

For finalizing accident management measures, NPCIL carried out a number of analyses of postulated severe accident scenarios for ascertaining the need for installing Containment Filtered Venting System (CFVS). This study indicated that owing to design features, some PHWR units do not need CFVS, whereas requirement was considered in remaining PHWR units and TAPS-1&2. Subsequently, based on literature survey and available information on different designs, detailed design of the system was taken up in-house in NPCIL. The aim of the design was to ensure containment depressurisation during severe accident and to achieve decontamination factor more than that considered in the radiological release assessment. Towards this, the design was validated on scaled model by conducting experiments simulating different conditions as expected in the accident in different PHWRs and TAPS-1&2 containments. As requirement of CFVS operation is much later into the accident progression, valving in of the system is envisaged to be manual and for facilitating manual action, system is adequately shielded and instrumented. CFVS is designed considering sesimic and design basis flood level requirements of PHWRs and TAPS-1&2. Development and validation of in-house design has taken substantial efforts and to save on time, regulatory review of the CFVS experiments and design reports was taken up in parallel. After regulatory review of the detailed design, CFVS installation will be taken up, though procurement actions have been initiated.

Hydrogen management in PHWRs is envisaged through passive catalytic recombiner devices (PCRDs) and means to promote intermixing of containment atmospheres. While finalizing accident management measures, when the need to install indigenous PCRDs became clear, the work that was in progress to develop the technology was expedited. In parallel, substantial efforts were put in analysing accident scenario for deciding hydrogen source term. Three designs of PCRDs developed in BARC were tested and one design was chosen based on factors such as effectiveness, robustness and economics. In a collaborative project of BARC and NPCIL, a large number of experiments were conducted in hydrogen recombiner test facility at R&D Centre, Tarapur. This testing included dry tests (05% to 3.5% hydrogen concentration) and in the presence of steam (0.5% to 10% hydrogen concentration). Design, testing and characterization of PCRDs was a time and resource intensive activity. After finalization of design, technology is transferred to an industrial unit for bulk production of PCRDs. In line with the production schedule, these PCRDs will be installed in NPPs.

For KK NPP hook up points for external water injection to reactor coolant system, steam generators and fuel pool cooling system is already implemented. Additional power source and water inventory are provided. For TAPS 1&2, hook up points for external water injection to reactor pressure vessel, emergency condenser, containment spray and fuel pool cooling system are also implemented.

All identified post Fukushima related safety up-gradations have been made as a part of design requirements in reactors under construction and commissioning.

In the NPPs that are already under operation, comparison is made with the current standards as a part of Periodic Safety Review (PSR), which is done once in five years, and it is determined whether the safe operation of the plant could be further enhanced by means of safety improvements that are practicably reasonable. Details of PSR is covered in article 14.

18.1.1 Regulatory Review and Control activities

The regulatory review process at AERB includes review of the submitted information against the safety requirements specified in its safety codes. The application of concept of Defense In Depth (DID) in design of NPP is one such requirement. The review and assessment process is performed by AERB based on the information submitted by the applicant to demonstrate the implementation of concept of DID in the design of proposed NPP. The analysis of this information enables AERB to make decision on the acceptability of the plant in terms of safety during normal operations and AOOs, Design Basis Accidents and DEC, that have potential to cause exposure of the workers or the public.

The prerequisite for issue of consent for construction is the review of design safety of the proposed NPP. Details of the process is covered in article 14.

The evaluation takes into account experience feedback from similar NPPs, new development and experimental results.

In carrying out its review and assessment of design prior to issue of consent for construction, AERB determines that the proposed design of NPP meets the safety requirements as specified in the AERB Safety Codes. The review and assessment by AERB also includes consideration of the applicant's organization and management to ensure that the proposed construction will meet the quality requirements as envisaged in the design. The applicant is required to demonstrate that the safety management system put in place is comprehensive and it would ensure that the relevant activities are carried out in a planned and systematic manner and that the quality of work is in accordance with the approved procedures and nuclear industry practices. For this, AERB reviews the QA manuals of the utilities for design, procurement, fabrication, construction, commissioning and operation. It is the responsibility of the utilities to ensure that the vendors employed by it for carrying out different activities, follow a QA programme commensurate with the safety requirements.

Basis Of Acceptance (BOA) documents, (the documents to confirm that the components are manufactured in compliance to the design requirements), for identified safety related components/equipment and FOAK systems are prepared by utility and submitted to AERB for review and acceptance.

To ensure design implementation and adherence to appropriate QA during construction, Regulatory Inspections are carried out by AERB. These regulatory inspections are generally carried out at a frequency of four inspections in a year during construction. In addition to normal regulatory inspection, AERB also identifies certain critical activities during construction as hold points for which the utilities are required to inform AERB in advance for deputing its representative to witness or carry out inspection or tests, as may be necessary

AERB has also implemented event reporting system during construction and commissioning of NPP.

18.2 INCORPORATION OF PROVEN TECHNOLOGY

As per regulatory requirement, structures, systems and components (SSC) important to safety for a nuclear power plant should be designed, fabricated, inspected and constructed in accordance with the applicable codes and standards.All the regulatory requirements specified in the different AERB Codes and other regulatory documents are complied with. If the design, construction, manufacture, inspection and maintenance of civil structures, mechanical, electrical, Instrumentation & Control equipment and systems are done by using the international codes & standards, it should be acceptable to AERB.SSCs important to safety of a nuclear power plant should preferably be of a design that has previously been used in equivalent applications. SSCs of high quality standard must be used for all safety related application. Technology that has been qualified and tested previously be applied. NPP designers should identify codes and standards to be used for designing of items important to safety and evaluate them to determine their applicability, adequacy and sufficiency. It is required to be demonstrated that the quality of the design is commensurate with the associated safety function.

When a new design or feature is introduced or there is a departure from an established engineering practice, safety is to be demonstrated by means of appropriate supporting research programmes, performance tests with specific acceptance criteria, or utilizing the operating experience from other relevant applications.All these systems are adequately tested during commissioning to verify that the expected behaviour is achieved.Performance of the new design/equipment is monitored while in service to verify that the behaviour of the system/equipment is as per design.

Proven and conservative design measures with well-established engineering practices are adopted in safety system design for design basis accidents. Additional safety systems/features for preventing and/or mitigating the consequences of design extension conditions leading to accidents situations without core melt, are designed with proven engineering practice using diversified principle. Complementary safety features for mitigating the consequences of any core melt scenario are designed based on practical approach backed up by research and development.

The equipment important to safety are qualified to operate in the environment expected under accident conditions. SSCs required to perform necessary functions during earthquake are qualified by testing/analysis to demonstrate their pressure boundary integrity or structural integrity for two levels of earthquake i.e. OBE & SSE, depending on the seismic categorization. Equipment which have moving components viz, relays, valves, actuators, starters, push buttons etc. are tested on a shake-table for their functional performance for the two levels of earthquake.

For structural analysis, state of the art codes are used. Codes are validated with both benchmark classical problems and experimental tests and results.

Computer codes are used for safety analysis during normal operation and accident conditions. Codes for studying Thermal hydraulics, Core physics, Neutronics, High temperature phenomena and Core concrete interaction during severe accidents, fuel behaviour and radioactivity release, containment behaviour, etc. have been developed. These codes are developed in-house and are benchmarked with results of experiments conducted at national and international laboratories, by participating in standard problem exercises of IAEA, coordinated research programmes of IAEA and technical exchange programmes.

Design and implementation of computer based systems has matured over last several years and with current state of technology. It has been possible to develop computer based systems for carrying out functions important to safety in nuclear power plants and also to demonstrate their fitness-for-purpose. In nuclear power plants, both new and old, computer based instrumentation and control (I and C) systems are used increasingly both in safety related applications, such as some functions of the process control and monitoring systems, as well as in safety critical applications, such as reactor protection or actuation of engineered safety systems. Since analogue equipment are becoming obsolete in earlier designed reactors, digital equipment are offering a practical replacement for the same. The digital instrumentation and control equipment are now extensively used in the newly built reactors in India. For qualification of digital technology for use in NPPs, an elaborate process of Independent Verification & Validation (IV&V) has been implemented.

18.2.1 R&D Facilities for Assuring Safety of NPPs

BARC, IGCAR, other national R&D facilities including NPCIL in-house facilities provide R&D support for the nuclear power programme. The overall program is aimed to enhance the safety margins of the current reactors, establishment of improved safety features of the proposed reactor designs and perform adequate testing for all FAOK systems to demonstrate its performance. Several R&D set ups are operational and mock up facilities are being constructed from time to time to satisfy the latest safety requirements of NPP.

BARC is presently involved in the following key activities as a part of R&D efforts related to NPP safety:

- Experiments for validation of leak flow models for PHWR pipe cracks and humidity sensor development for steam line leak flow detection
- Development of ultrasonic technique for pressure tube ID measurement with remote operated drive
- Development of clad burst correlation for PHWR clad
- Development of an integrated severe accident code PRABHAVINI for PHWRs
- Development of CFD code PINAK for Molten Fuel Coolant Interaction specific to PHWRs
- Adaptation of code ASTEC for PHWR severe accident analysis for CESAM project and development of models for Passive Autocatalytic Recombiners
- Experiments to establish analytical model DBHUPA for analysing PHWR debris bed heatup.
- Experiments for determination of channel disassembly criteria for PHWR
- Large Scale Molten Material Coolant Interaction experimentation for PHWR
- Experiments for qualification PCRD
- Technical assessment of Calandria behaviour under Severe Accident for PHWR
- TAPS-BWR and KK-VVER specific Plant Analyser development for SAMG verification
- Generic containment benchmarks and alternate TMI benchmark exercises under SARNET programme to improve the understanding of severe accident code ASTEC
- Experiments on ultimate load capacity of containment using BARC containment model (BARCOM) facility
- Experiments on AHWR Thermal-hydraulic Test (ATTF) facility with full height simulation including the Fuel Rod Cluster Simulator (FRCS).
- Experiments for design validation for AHWR core catcher and CFVS

IGCAR is involved in R&D activities related to fast reactor technology. Some of the key test facilities set up by IGCAR are:

- A conceptual core design for 100 MWt Metal Fuel Test Reactor, wherein A 5/8th scale 90° sector model simulating the hot pool of future FBRs has been commissioned for conducting hydraulic studies in water
- Flow induced vibration characteristics of a cluster of subassemblies of the core of FBR
- Ultrasonic imaging based procedure has been developed for assessment of bond integrity of Zirconium lined ferritic steel (T91-Zr) double clad for metallic fuel applications
- RISHI (Research facility for Irradiation studies in Sodium at High temperature)
- RABITS (Rupture And Ballooning In TubeS) for testing the ballooning behaviour of clad tubes

- Online Nuclear Emergency Response Decision Support system (ONERS)

NPCIL is involved in R&D activities related to 700 MWe PHWR based NPP. Some of the key activities are:

- Experiments have been conducted for arriving at optimal spray nozzle design & spray ring header configuration with full scale facility at KAPS colony and facilities at IITB. Iodine scrubbing experiments conducted. These have been successfully presented to AERB towards dome erection clearance.
- 700 MWe Fuelling Machine Test Facility is established and both Fuelling Machine Heads of KAPS-3 are tested with low temperature, high pressure operations. Full primary temperature & pressure tests are proposed.

Apart from the above, AERB has its own safety research institute set up at Kalpakkam, Tamil Nadu. Some of the R&D activities undertaken are:

- Reactor safety studies (Deterministic and probabilistic approach)
- Consequence analysis and Atmospheric dispersion modelling
- Remote Sensing and Geographic Information System Applications
- Development of Simulation tools to predict flood inundation patterns
- Degradation of toxic organic pollutants from liquid waste

18.2.2 Regulatory Review and Control activities

AERB reviews the design of the plant with respect to applicable codes and standards. Applicability of the industrial code used for design, classification of SSCs, fitness for use, seismic categorization, loading of SSC as per design, etc. are thoroughly reviewed. Proven industrial codes for design, proven engineering practices, quality assurance programme, manufacturing practices, erection and commissioning procedures are reviewed to see compliance to regulatory requirement. Though proven technologies are preferred but innovative and first of a kind systems (FOAK) are also accepted. For innovative and first of a kind system, design and working principle are thoroughly reviewed. Utility is needed to submit necessary technical documents substantiating the design. It is also expected that performance of the system is demonstrated in scaled model/mock up facility. During commissioning, detailed tests need to be carried out to demonstrate the capability of the system to perform intended function in an integrated manner

Presently the R&D facilities at BARC, IGCAR, CSRP, IITs etc. are supporting AERB for verification of new design features considered in the plant design. Further, AERB has its own Safety Research Institute (SRI) carrying out research activities in areas of regulatory interest. Design details of specific test facilities, testing methodology, test procedure, acceptance criteria, test results, etc. are reviewed by AERB at appropriate time. Performance tests are witnessed by AERB as and when required. However, the final acceptance of the systems is based on the established safety review process in AERB.

Pre-consenting review of Design of Indian Pressurised Water Reactor:

BARC jointly with NPCIL is working for finalizing the design of Indian Pressurised Water Reactor (IPWR). IPWR is an indigenous PWR design with a power rating of 2700 MWt – 900 MWe with advanced safety features, including passive safety systems. The R&D work is in progress in the area of development of material, equipment and analysis. AERB is carrying out a pre-consenting review of design of IPWR based on the request from BARC.

18.3 DESIGN FOR RELIABLE, STABLE AND MANAGEABLE OPERATION

AERB has established the requirement for NPP design for reliable, stable and manageable Operation. These include:

- Redundancy, diversity and fail safe approach for safety critical systems

- Man-machine interface is designed to provide the operators with comprehensive & easily manageable information
- Providing interlocks & automatic actions. Design provides adequate time for operator to take necessary action.
- Ergonomically designed control panels
- Layout to facilitate operability and maintainability
- Working areas and working environment are given due consideration to personnel comfort.
- Extensive dependence on automatic action based on plant parameters without needing human intervention.
- Continuance of safety function based on plant parameter without operator intervention in the initial period.

Established design codes are used for designing systems incorporating sufficient margin to serve for entire life time of the plant. Reliable equipment and component are normally used in the design for which sufficient operating experience available. Limiting condition for operation, limiting safety system setting and safety limits are used for safety of the NPP. The plant is operated strictly adhering to written procedures and Technical Specification for Operation. Operators of the plant are imparted theoretical and practical training including training in full scope simulator for normal, off normal and accident conditions. Periodic refresher training is also imparted to the operator and evaluation of the effectiveness of training is done.

In the plant, provision is made for periodic monitoring, testing, sampling and inspection to assess ageing mechanism predicted at the design stage and to help identify unanticipated behaviour of the plant or degradation that might occur in service. Required data is generated for these equipment for ageing management and estimation of their residual life.

In cases where the design life of equipment/ component is less than the design life of the plant, and mid-term in-situ replacement of the equipment is warranted, adequate provision is made in the design particularly for the in-core equipment, to facilitate such replacements.

A qualification programme for equipment/ component important to safety is implemented to verify that they are capable of performing their intended functions when necessary, and in the prevailing environmental conditions, throughout their design life, with due account taken of plant conditions during maintenance and testing.

Configuration control mechanism is established to record all necessary changes made in the plant during operation. Periodic safety review of the plant is carried out to assess the fitness for use and to incorporate necessary upgrade complying current safety standards. Necessary safety reviews are carried out whenever required.

18.3.1 Regulatory Review and Control Activities

Safety requirements in regulatory document specify that, for the indigenously designed NPPs, design organization supplies adequate information towards safe, reliable and manageable operation and maintenance of the plant. Design organization also support subsequent plant modifications and provides assistance for preparation of administrative and operational procedures.

In case of NPPs of external design, it is required that responsible organization establishes a formal system within its management for ensuring the safety of the plant design throughout the lifetime of the NPP. This includes arrangements with external organizations for assignment of tasks where detailed specialized knowledge is not available with the design authority. These external organizations including original designers (vendors) are required for maintaining their specialized knowledge of design and sharing the same with the design authority within the responsible organization during the lifetime of the plant.

The implementation of the requirements for human factors / human machine interface is addressed in detail in chapter on Article 12: Human Factors. The regulatory requirements specify that the aspects of design, having implications on operability, shall be reviewed by the utility. The merits in developing such a methodology include acceptance of the design by the utility for ensuring proper operation, maintainability, layout, inspectability etc. in the new designs. AERB ensures compliance to this requirement during the safety review for construction consent.

18.4 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

The stage wise consenting process of AERB ensures that the safety in design is comprehensively reviewed prior to issuance of consent for construction. The regulatory review and assessment determines that in the design of NPP, proper emphasis is placed on prevention of accident as well as on its mitigation. The defence in depth principle is as per the intent elaborated in the regulatory documents. All NPPs including those under design and construction have undergone a special review following Fukushima accident and enhancements as required to cater to natural events have been incorporated in the design. Technologies used in the design and construction of the NPPs, are either proven by experience or otherwise qualified by testing or analysis. Human factors and man machine interface have been given important considerations among others in the design of NPPs. The objective of design has been to ensure reliable, stable, safe and easily manageable operation of the plant. Therefore India complies with the obligations of Article 18 of the Convention.

The regulatory requirements with respect to siting and design of NPPs in India are consistent with the Vienna Declaration on Nuclear Safety.

ARTICLE 19: OPERATION

Each Contracting Party shall take the appropriate steps to ensure that:

i. **the initial authorisation to operate a nuclear installation is based upon an appropriate safety analysis and a commissioning programme demonstrating that the installation, as constructed, is consistent with design and safety requirements;**

ii. **operational limits and conditions derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation;**

iii. **operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures;**

iv. **procedures are established for responding to anticipated operational occurrences and to accidents;**

v. **necessary engineering and technical support in all safety-related fields is available throughout the lifetime of a nuclear installation;**

vi. **incidents significant to safety are reported in a timely manner by the holder of the relevant licence to the regulatory body;**

vii. **programmes to collect and analyse operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organizations and regulatory bodies;**

viii. **the generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable for the process concerned, both in activity and in volume, and any necessary treatment and storage of spent fuel and waste directly related to the operation and on the same site as that of the nuclear installation take into consideration conditioning and disposal.**

19.0 GENERAL

The requirements for licensing of NPPs for operation emanate from the Atomic Energy Act 1962 and rules framed thereunder. National laws pertaining to NPP are given in detail in Chapter on Article 7: Legislative and Regulatory Framework. Based on these requirements, the system of licensing, inspection and enforcement has been established. AERB code of practice on regulation of Nuclear and Radiation Facilities, AERB/SC/G and AERB Safety Guide AERB/SG/G-1 on “Consenting Process for Nuclear Power Plant and Research Reactor” establishes the entire licensing process for NPPs. The licensing process is summarised in Chapter on Article 14: Assessment and Verification of Safety. Further, AERB safety code “Nuclear Power Plant Operation”, AERB/NPP/SC/O (Rev. 1) establishes requirements related to operation of NPPs and several safety guides issued under this Code describe and make available methods to implement specific requirements of the Code.

19.1 INITIAL AUTHORIZATION

Prior to issuance of consent for construction, AERB completes the review of Preliminary Safety Analysis Report (PSAR) submitted by the licensee. At this stage, a large part of the review and assessment effort is directed to the safety analysis of design basis events provided by the applicant. The review and assessment process considers whether the applicant’s list of Postulated Initiating Events (PIEs) is complete and acceptable as the basis for the safety analysis. AERB determines that the PIEs, type of analytical considerations and assumptions are in conformance with applicable safety guides. Further, the engineering systems are qualified to meet the functional requirement for which they were designed, under all situations considering environmental conditions, ageing etc. Aspects of review of safety analysis are given in detail in the Chapter on article 18: Design and Construction.

On completion of construction, a Regulatory clearance for commissioning of PHWR based NPP is sought by the licensee as per the regulatory requirement of AERB/NPP&RR/SG/G-1 and guidance provided in AERB/SG/O-4. Recently, AERB has prepared a regulatory guide for commissioning of PWR based NPPs, which was updated based on the experience gained during the commissioning of KKNPP-1 (AERB/NPP-PWR/SG/O-4 C: 2014).

There are three major phases of commissioning namely; (i) Phase-A: pre-operational tests, (ii) Phase-B: Initial fuel loading, pre-critical tests, first approach to criticality (FAC) and low power tests and (iii) Phase-C: Power ascension tests

For a typical PHWR, such phases are indicated in the table below:

Table - 6 : Phases of commissioning of PHWR

Phase	**Stages of Commissioning**	
	No.	**Activity**
A	i.	Hot conditioning or passivation of the primary system and light water commissioning
	ii.	Fuel loading of the reactor core, and borated heavy water addition to moderator systems for flushing in specified limited quantity
	iii.	Addition of heavy water to primary heat transport system
	iv.	Bulk addition of heavy water to moderator system with minimum specified boron level in heavy water to prevent criticality
B	i.	Initial approach to criticality
	ii.	Low power reactor physics tests and experiments.
C	i.	Initial system performance tests at low, medium and rated power levels as determined by the stable operation of the turbine.
	ii.	System performance at rated power.

Before start of commissioning activities, utility prepares a comprehensive programme for the commissioning of plant components & systems and submits the same for review and acceptance by AERB.

The commencement of operation of an NPP begins with approach to the first criticality. This is a major step in the licensing process. At this stage utility demonstrates to AERB its preparedness to commence operation of the NPP. This requires completion of all activities with requisite approvals, pertaining to the following:

a. Final as built drawings for the plant SSCs and Final Safety Analysis Report.

b. Evaluation of safety analyses in view of changes in design, if any.

c. Quality records (such as construction completion certificate, history dockets etc.) after construction of the plant components and systems, and the program for their operation.

d. Pre-Service Inspection (PSI).

e. Establishment of organization for plant operation, training, qualification & licensing of the operating personnel, as per AERB requirement.

f. Technical Specification for Operation specifying operational limits and conditions.

g. Operating instructions and procedures for commissioning and operation of the plant including emergency operating procedure.

h. Establishment of physical protection system and Nuclear Security Aspects.

i. Radiation protection program.

j. Emergency Preparedness and Response Plans.

k. Waste management programme.

AERB carries out review and assessment of preparedness of NPPs to satisfy itself that the plant has been built in accordance with the accepted design, and meets all the regulatory requirements.

AERB has undertaken a comprehensive review of the prevailing safety requirements to ascertain whether they would require further revision in the light of lessons learnt from the Fukushima accident. In view of this, the following aspects are given special attention while issuing initial authorization for operation of NPPs:

- Implementation of safety upgrades in reactors as well as spent fuel storage, identified based on special safety assessment post Fukushima
- Establishment of surveillance and testing programs and limiting conditions of operation relevant to these upgrades
- Establishment of plant-specific accident management guidelines and training to NPP operators
- Demonstration of design safety through analysis taking into account of severe accident scenarios and radiological acceptance criteria specified in AERB/NF/SC/S (Rev. 1), 2014
- Upgradation of infrastructure for emergency preparedness and response plans

Before licensing regular operation, AERB carries out review and assessment of the results of commissioning tests for their consistency with design information and with the prescribed operational limits and conditions. Any inconsistency at this stage is resolved to the satisfaction of AERB. At this stage, the utility revises the PSAR taking into account all the changes that have been carried out and submits Final Safety Analysis Report (FSAR), which forms one of the licensing documents for operation of the unit.

The review and assessment by AERB also includes consideration of the applicant's organization, management, procedures and safety & security culture, which have a bearing on the safety of the operation of the plant. The applicant should demonstrate with the necessary documentation that there is an effective safety management system in place, which gives the highest priority to nuclear safety and security. The typical organisation for plant operation established at an Indian NPP is given in Annex 19-1.

19.2 OPERATIONAL LIMITS AND CONDITIONS

The licensee prepares the Technical Specifications for operation before approach to first criticality, based on the inputs from the design and safety analysis. AERB safety Guide AERB/SG/O-3: Operational Limits and Conditions for Nuclear Power Plants provide guidelines for preparation of this document, which is submitted to AERB for review and approval. Adherence to Technical Specifications during operation is mandatory. A Technical Audit Engineer at the Station independently verifies compliance with all the clauses of Technical Specifications and reports to station management. The compliance with the requirements specified in Technical Specification is further verified through regulatory inspections by verifying station's records.

The Technical Specification document is issued in two parts. Part A contains the technical specifications and station policy clauses, bringing out the mandatory requirements to be adhered to during operation. Part-B is explanatory in nature and outlines the bases for arriving at different conditions/requirements in technical specifications for operation.

Technical Specifications (Part-A) consists of following sections:

i. Safety Limits

ii. Limiting Safety System Settings (LSSS)

iii. Limiting Conditions for Operation (LCO)

iv. Surveillance Requirements

v. Administrative Requirements

If a change in any section of the Technical Specification becomes necessary, based either on operating experience or new findings consequent to changes in safety analysis, the same is submitted to AERB for review and approval. A general review of the document is carried out once in five years.

19.3 PROCEDURES FOR OPERATION, MAINTENANCE, INSPECTION & TESTING

The safety code on 'Nuclear Power Plant Operation', AERB/NPP/SC/O (Rev 1) requires that all the activities in the NPP be carried out as per the well laid down operating procedures. The procedures should be prepared, tested and approved as per the standard guidelines developed for the same. Based on these guidelines, the plant management prepares various procedures for commissioning and operation of all systems, maintenance, inspection, testing, and surveillance requirements. The procedures also include conditions dealing with plant under normal operation and anticipated operational occurrences as well as appropriate actions for accident conditions including design basis accidents. These documents are normally prepared by plant personnel in co-operation with the designers and suppliers. The Plant Management ensures that the aspects of Quality assurance are duly considered in the preparation, review and approval of these procedures. All the approved procedures are available to the users on plant local area network and hardcopy is maintained in main and supplementary/back-up control room.

19.4 PROCEDURES FOR RESPONDING TO OPERATIONAL OCCURANCES & ACCIDENTS

At present, all NPPs have procedures for handling various anticipated operation transients and accident conditions. These procedures are commonly called Emergency Operating Procedures (EOPs). These EOPs are unique to each unit in the station and independent of other stations. In addition to the above, several unit-specific administrative procedures are also prepared, which include shift change over procedure, station work permit procedure, radiation protection procedure, engineering change procedure, temporary change control procedure, etc.

NPCIL HQ has developed generic document for Accident Management Guidelines (AMG) of PHWRs based NPPs. This generic document is a comprehensive technical document, prepared considering the guidelines given in IAEA Safety Guide (IAEA-NS-G 2.15): 'Severe Accident Management Programme for Nuclear Power Plant'. The document also contains guidelines for dealing with postulated accident conditions in spent fuel storage pools. Based on this generic document, the following station-specific accident management guidelines have been prepared for all NPPs:

- Severe accident prevention guidelines
  - injection of water into steam generators
  - injection of water into primary heat transport system
- Severe accident mitigation guidelines
  - maintaining calandria heat sink by injecting water to calandria
  - maintaining calandria vault heat sink by injecting water to calandria vault

- controlling reactor building conditions
- Severe accident ultimate guidelines
  - reduction of containment pressure
  - reduce containment atmosphere flammability/hydrogen
  - mitigate fission products release

The station-specific accident management guidelines also cover the transition criteria from EOPs to accident management guidelines. The qualified / licensed operating staffs at all the stations have undergone training on the transition criteria and the accident management guidelines. Their re-training frequency is set at once in three years. As part of long term measures, various hardware provisions/additional equipment required for these accident management guidelines are under implementation at all Indian NPPs. Passive Catalytic Recombiner Devices (PCRD) are to be deployed for hydrogen management inside containment building. Safety analysis for estimating the required number of PCRD and their location has been carried out. The design of Containment Filtered Venting System (CFVS) has been finalized after due testing and regulatory review is in progress.

Apart from these, there are site-specific procedures for conducting site-emergency exercise and handling the off-site power failure situations, which involves multiple units/facilities at the site.

India has adopted twin unit concept for establishment of nuclear power plants in the country. Each twin unit station has both units essentially similar in design. A site having multiple nuclear power stations also follows the same concept of twin unit station with adequate physical separation between them. However, each site has a centralized waste management facility, a centralized emergency equipment center, a centralized emergency control center and a centralized Fire station, which takes care of the needs of each station/facility located at the site.

In view of the non-sharing of safety systems among the multiple stations at a site and development of emergency operating procedures and accident management guidelines for each unit, the safety concern related to multi-unit/multi-facility sites, as appropriate, are addressed.

19.5 ENGINEERING AND TECHNICAL SUPPORT

NPCIL manages all the presently operating NPPs through the Directorate of Operation set up at its Head Quarters at Mumbai. This Directorate monitors the operational and safety performance of NPPs and provides the necessary engineering and technical support. The Directorate also acts as interface between plant management and AERB. For achieving these objectives, the Directorate of Operation also derives support from other technical groups at Headquarters, which include Directorates of Engineering, Safety, Quality Assurance and Procurement. These groups at headquarters also provide Design, Engineering and Technical support to units under construction and commissioning. NPCIL also enters into memoranda of understanding with Research and Development and academic institutions so as to avail additional engineering and technical support as and when required.

Directorate of Technology Development, NPCIL provides technical support to all NPPs in the area of Remote handling techniques and tool development, optimization of NPP construction time, residual life assessment of SSCs, application oriented projects to provide timely solutions to the problems emanating from operating stations/project under construction, experiment oriented projects for validating new designs and in-house developed computer models/codes In addition to the technology development activities reported in the Indian National report to the Sixth Review Meeting of CNS, some of the new/updated activities undertaken in the reporting period are:

- NPCIL Thermal Hydraulic Test Facility (NTTF) commissioned and carried out preliminary low power Passive Decay Heat Removal System (PDHRS) experiment to establish the efficacy of this system. NTTF is part of the "Integrated Thermal Hydraulic Test Facility Tarapur "(ITFT) at R&D centre Tarapur (Fig. 19.2).

- Hydrogen Recombiner Test Facility is operational and more than 50 experiments have been conducted. Performance testing of Passive Catalytic Recombiner Devices (PCRDs) designed by BARC has been completed and optimal design finalised.
- A large number of experiments to establish Decontamination Factor have been conducted in scaled Containment Filtered Vent System (CFVS) facility. Full scale prototype CFVS vessel is fabricated and internals being assembled (Fig. 19.2) Environmental Qualification Facilities are functional and more than 300 tests conducted.

Electronic systems R&D group concentrates mainly on development of electronics and computer based controls and instrumentation. The laboratory facilities for electronics and computer based systems are established at NPCIL headquarters, Mumbai.

At the plant level, the Technical Services Section, which provides support in monitoring and review of operational and safety performance, is also equipped to provide the necessary engineering and technical support. Based on the special safety assessment post Fukushima Accident, a centralized On-Site Emergency Support Centre common to all NPPs at a site is envisaged to be constructed within the exclusion zone (Please refer section 16.5.2 (i) for details). Review of generic design of the facility has been completed by AERB. Engineering support is being provided by NPCIL HQ to each NPP site for design, construction and commissioning of the Centre specific to the each site.

19.6 REPORTING OF INCIDENTS SIGNIFICANT TO SAFETY

AERB safety code on 'Regulation of Nuclear and Radiation Facilities', AERB/SC/G specifies the reporting obligations of the Plant Management. AERB/SG/O-13 on Operational Safety Experience Feedback on Nuclear Power Plants issued under the Code of Operation provides guidance for reporting events to regulatory body. The detailed reporting criteria for the events are provided in the Technical Specifications for Operation.

Events of relatively lower safety significance (limited consequences from safety point of view) are reported as 'Event Report' to AERB in a prescribed format as part of the minutes of the Station Operation Review Committee (SORC). However, Events with relatively higher significance for safety are required to be reported as Significant Event Reports (SER) as per the reporting criteria specified in Technical Specification for Operations. These events are reported to AERB in following three stages:

i. Prompt Notification

   Prompt Notification in the prescribed format is sent within 24 hours of the occurrence of the event

ii. Significant Event Report

   A detailed significant event report (SER) in a prescribed format for SER is submitted within a period of 20 days from the date of occurrence of the event.

iii. Event Closing Notification Report

   Event Closing Notification Report (ECNR) in a prescribed format is submitted for those significant events for which root cause could not be established within 20 days (reporting time for significant event report). ECNR indicates completion of all investigations pertaining to the event.

Number of significant events at operating NPPs during the last three years 2013, 2014 and 2015 were 34 (33 events were below INES rating scale, 1 event of INES rating 1), 35 (34 events were below INES rating scale, 1 event of INES rating 1) and 42 (all events were below INES rating scale) respectively. The information on events rated at Level – 1 on INES is given under Article – 6.

All the SERs are reviewed by AERB and recommendations arising out of the multi-tier review process are addressed in a time bound manner.

During Operational Safety Review Team (OSART) mission for Rajasthan Atomic Power Station (Units 3&4); one of the recommendations of the OSART team was to improve root cause analysis in order to systematically identify root causes and other learning opportunities in order to prevent recurrence of events. Keeping in view of the above and in order to increase the awareness of IRS, RCA and CA, AERB organized IAEA workshop on 'IRS, RCA and CA' in November, 2013. Officers from organizations such as NPCIL, BARC, IGCAR and AERB have participated in this workshop.

In order to utilize the experience gained by the participants and thereby improve the existing mechanism of RCA, directive was issued to all the stations to carry out RCA with more than one method and provide more details in future SERs. Subsequently, utilities have complied and are providing details of RCA along with the SERs.

Apart from the reporting requirements of operational events, licensee has established a Low Level Event (LLE) programme since year 2005 as a performance improvement programme by identifying and trending minor issues including issues related to safety culture. Stations send the quarterly reports on LLEs to Operations Directorate at headquarters, where all the LLE reports are reviewed and generic issues related to all the stations are identified and suitable action is proposed to address the same. The awareness created at stations has resulted in increased reporting of LLEs. The periodical review of LLEs is helping stations in identifying & addressing the generic issues in stations.

A system for reporting Extraordinary Nuclear Events has been established in order to meet the requirements under CLND Act, 2010.

19.7 OPERATING EXPERIENCE FEEDBACK SYSTEM

AERB recognizes operating & regulatory experience as input for 'Continual Safety Improvement' and has established a structured Operating Experience (OE) program. AERB safety code on operation (AERB/SC/O) specifies the requirement for establishing operation experience feedback system at NPPs. AERB Safety Guide AERB/SG/O-13 on 'Operational Safety Experience Feedback on Nuclear Power Plants' provides guidance and procedure for establishing an Operating Safety Experience Feedback (OSEF) system based on national / international experience on management of safety related operational experience in NPPs. The OSEF system at NPPs and at NPCIL complies with the guidelines given in the safety guide.

NPCIL obtains reports of international events through IAEA-IRS, WANO, COG etc. These reports (both national and international) are reviewed at headquarters and applicable reports are sent to stations.

The organizational structure at Plant Level ensures that both national and international events are systematically analyzed through Operating Experience Review Committee (OERC) and appropriate actions are taken to prevent the occurrence of similar events in Indian NPPs. Station OERC comprises of members from Technical Services, Operation, Maintenance, Health Physics, Training and other relevant sections. The observations of this Committee are further reviewed in Station Operation Review Committee (SORC) for identification of safety related actions. Details of the operating experience feedback process is given in section 9.6 of Article 9.

The system ensures that events taking place at one NPP are communicated to other NPPs in India. The system also ensures that the information on events and corrective actions at one NPP is disseminated to other NPPs. Further, management of various NPPs interacts with each other at different levels. At these meetings, the information on various modifications to equipment and procedures is exchanged. These exchange meetings are held periodically.

At corporate level a ‘Flash Report’ is issued by Directorate of operations at NPCIL headquarters to all the stations for quick dissemination of information pertaining to the occurrence of an event in any plant. In addition, an ‘Operational Experience Feedback Report’ is also issued by headquarters on those events which have significant learning points for all the other stations of NPCIL.

In addition, to the reporting of events significant to safety (refer section 19.6), the plant management is also required to submit routine reports such as periodic performance reports, inspection & testing reports, health physics reports, environmental surveillance reports, waste management reports, minutes of Station Operation Review Committee (SORC) and other miscellaneous reports to AERB. The functioning of the operating experience feedback setup at the plant and the corrective actions taken in response to internal and external operating experience is monitored by AERB through the reports received from licensee and during regulatory inspections carried out twice in a year. Actions taken by licensee based on internal and external operating experience are also reviewed during renewal of license for operation every five years.

AERB has an independent OE program that utilizes the information obtained from national operating experience (Nuclear Power Plants /Projects), national regulatory processes such as licensing, regulatory inspection, safety review and enforcement and national workshops, seminars and technical conferences. It also obtain operational and regulatory experience from IAEA incident reporting system, international peer reviews (CNS, IRRS, OSART), Bi-lateral & multi-lateral co-operations with other regulatory agencies and regulator’s forums.

The program also plays a pivotal role in exchanging safety significant experience / information among different regulatory core processes (i.e. licensing, regulatory inspection, safety review and enforcement) and for the development of safety regulations. The overall structure of AERB OE program along with various OE Inputs & OE Outputs is depicted in the figure below.

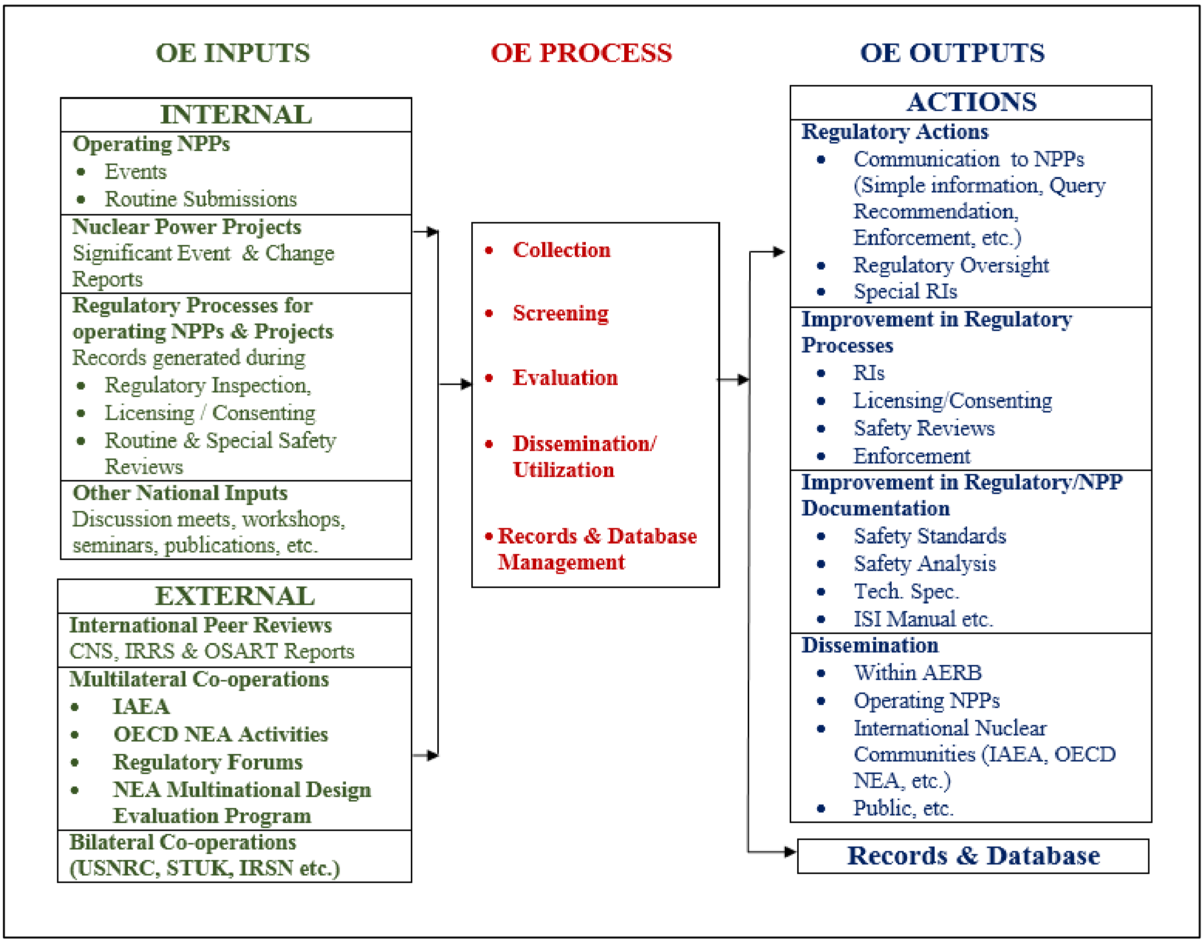


Figure - 5 : Structure of AERB OE program

19.8 MANAGEMENT OF SPENT FUEL AND RADIOACTIVE WASTE ON THE SITE

19.8.1 Spent Fuel Storage

Spent fuel is stored in a water filled storage bay provided at each NPP. These storage bays are designed to accommodate spent fuel accumulated during 10 reactor years of operation. In addition, space is also reserved for storing one full core inventory of fuel in case of exigencies. For storage of spent fuel beyond this capacity, additional facilities in the form of Away From Reactor-Spent Fuel Storage Bay and Dry Storage Facilities are created. All such additional storage facilities are subject to regulatory review and clearance.

19.8.2 Radioactive Waste Management

Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 specifies the requirement for obtaining authorization for safe disposal of radioactive waste arising out of operation of NPP. Further, AERB Safety Code on Management of Radioactive Waste, AERB/NRF/SC/RW, 2007 establishes the requirements, which need to be fulfilled for safe management of solid, liquid and gaseous radioactive waste disposal. This safety code deals with the requirements for radiation protection aspects in design, construction and operation of waste management facilities and the responsibilities of different agencies involved. In addition, AERB/SG/O-11 on Management of Radioactive Wastes Arising during Operation of NPPs gives guidelines for radioactive waste management.

Based on the above requirements, NPCIL has to establish a facility for management of radioactive wastes (solid, liquid and gaseous)at each NPP site prior to the commencement of operation. NPCIL demonstrates that the facility has necessary engineered systems and administrative procedures to exercise control on release of activity into the environment, as per the regulatory requirements.

19.9 LONG TERM OPERATION

All NPPs in India are required to establish a program for life management as per the requirement specified in AERB safety code for Operation (AERB/SC/O). The guidance for this is detailed in AERB safety guide on Life management of NPPs (AERB/SG/O-14), including the issues of (i) residual life assessment and (ii) safety upgrades towards addressing the current safety standards/practices. Through a comprehensive Ageing management Program (AMP), baseline data, operational history data and maintenance data for the SSCs are collected during the operation phase of NPPs. Effects of various operating conditions and degradation mechanisms on SSC are studied. On the basis of such assessment, specified conditions of components are monitored to determine the degradation in safety margin of components and the residual life of components are assessed

AERB has instituted a mechanism wherein a NPP can seek a renewal of operating license based on safety review. AERB issues license for operation of NPP for a specified period of 5 years based on the safety review and assessment of the application for renewal of license. In addition, every 10 years, Periodic safety review (PSR) is carried out by licensee and the PSR report is submitted to AERB for review in accordance with the guidelines given in AERB safety guide AERB/SG/O-12.

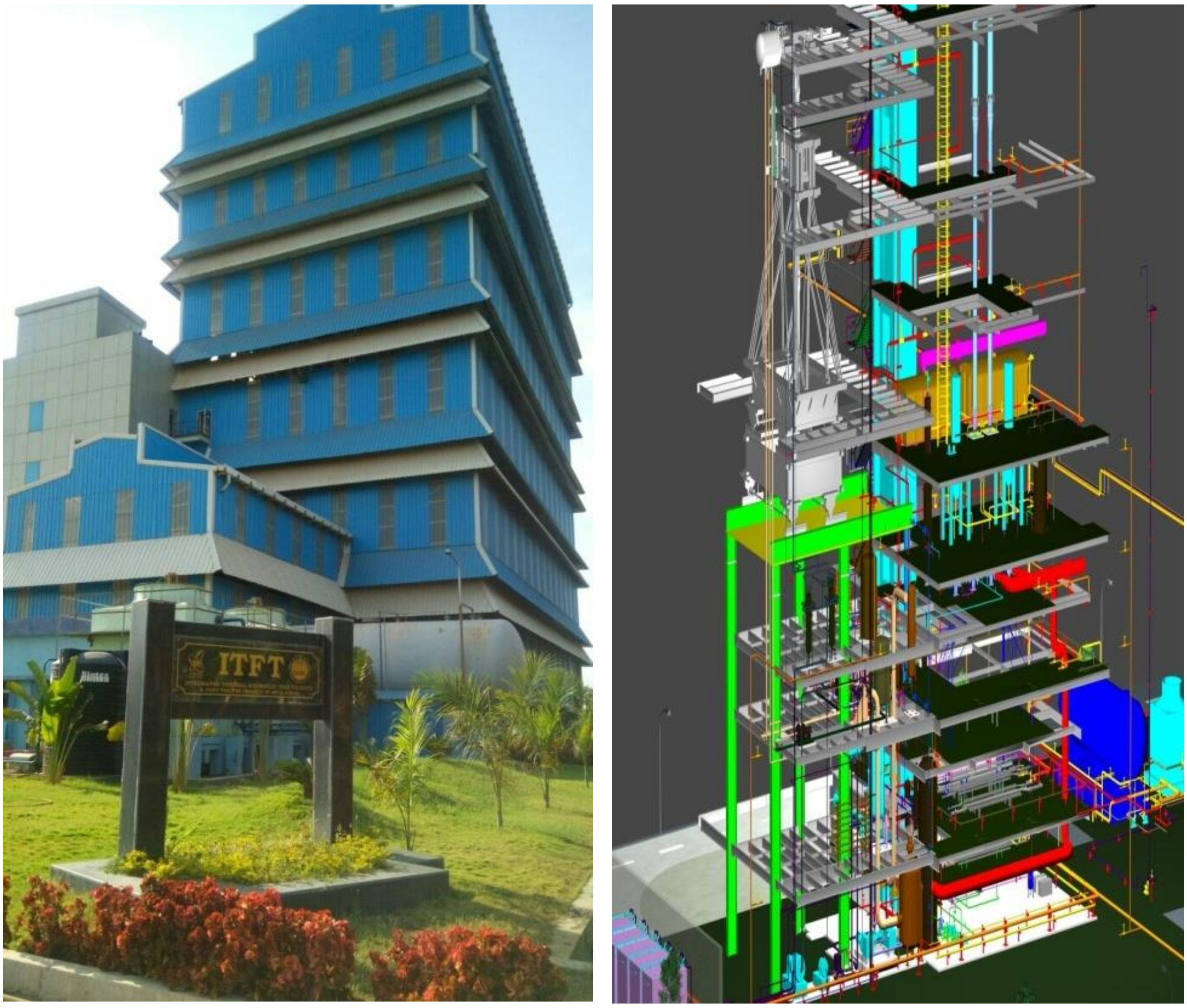
During the PSR review, safety assessment of NPPs is carried out considering the cumulative effects of ageing and radiation of plant, results of in-service inspection (ISI), system modifications, operational experience feedback status and performance of safety systems and safety support systems, revisions in applicable safety standards, technical developments, manpower training, radiological protection practices, deterministic and probabilistic safety analysis, hazard analysis, plant management structure, etc. These PSRs, carried out regularly over the lifetime of the NPPs facilitate evaluation of the NPP vis-à-vis the current requirements / practices. Based on these reviews necessary safety enhancements are identified and implemented. This facilitates addressing the Vienna Declaration on Nuclear Safety for the operating NPPs.

The regulatory approach followed for operation of NPPs in India allows the plant to continue operation as long as it meets the regulatory requirements and satisfies the safety case. As the plants get older, the ageing aspects receive increasing attention during various safety reviews including PSRs.

19.10 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

AERB/SC/G requires submission of the FSAR and Technical Specifications incorporating the experiences from commissioning process. The licensing process in India ensures that the initial authorisation for operation is given after a comprehensive review of the safety analysis and safety management system to ensure that the commissioning and operation of NPP is carried out in a safe and reliable manner. Operation of NPP is carried out within the operating limits and conditions specified in the Technical Specifications for Operations. In addition to the organisational set-up in accordance with the Technical specifications, an effective operating experience feedback mechanism has been set-up both at utility and AERB to ensure that both internal and external operating and regulatory experience is reviewed and appropriate corrective actions as applicable are taken at Indian NPPs as well as the projects under construction. Therefore, India complies with the obligations of the Article 19 of the Convention.

The operational practices of the NPPs and the system of periodic safety reviews along with the extensive operating experience feedback programme ensure continual safety improvements throughout the NPP operating life. This facilitates addressing the Vienna Declaration on Nuclear Safety with respect to the operating NPPs.



Views of Integrated Thermal Hydraulic Test Facility (ITFT)at NPCIL's Corporate R&D Centre, Tarapur

Views of Containment Filtered Vent System (CFVS) Vessel and internals during fabrication process

Annex 19-1: Typical Organisation at NPP

NPCIL has established a well-defined functional organization for each station. A typical organization chart is annexed for reference. The functional responsibilities of various wings of the organization to conduct safe, orderly and efficient operation of the Station are described below:

STATION DIRECTOR (SD) is the Head of station management of NPP. He has the overall responsibility for the safe operation of the plant and implementation of all relevant policies, statutory requirements and radiation protection rules and other instructions and procedures laid down by the operating organization for plant management. He is also responsible for ensuring that the requirements of AERB are complied with. He is also responsible for training, qualification and licensing of operating personnel, in accordance with the approved laid down procedures.

The SD ensures compliance with the technical specifications for operation, which detail the operational limits and conditions. In addition to the overall responsibility for ensuring the safety of the Station and the public, his responsibilities also include:

- Prompt notification of deviations from established technical specification limits and conditions in accordance with procedures.
- Maintenance of quality assurance in all activities at the Station including in maintenance, testing, examination and inspection of structures, system and components.
- For ensuring that modifications to plant configuration are carried out only after due approval by AERB as per the laid down procedures.
- Assumes the role of site emergency director in case of an emergency.
- Liaison with HQ, AERB and other statutory bodies.

In discharge of his responsibilities, Station Director is assisted by a team of operations personnel, responsibilities of whom are described in detail in the Technical Specification and Station Policy documents for station operation. Some of these are summarized below:

CHIEF SUPERINTENDENT (CS) is responsible for coordinating the safe and orderly operation and maintenance of the station / systems in accordance with approved procedures. Operation, Maintenance, Technical Services, Training and Quality Assurance Superintendents assist him in this regard.

TECHNICAL SERVICES SUPERINTENDENT (TSS) is responsible for:

- Engineering assistance required to efficiently operate the station/systems at optimum performance level.
- Performing engineering/technical studies and reviews.
- Issuing of work plans for specific jobs during operation and shutdowns.
- Reactor Physics and fuel management.
- Chemistry control of the systems.
- Upkeep and arranging updating of all technical documents including all design manuals and drawings.

OPERATION SUPERINTENDENT (OS) is responsible for:

- Safe operation of station / systems as per approved objectives, procedures, policies and within the limits and conditions laid down in the Technical Specifications.
- Bringing to notice of Station Operation Review Committee (SORC) members deviations / deficiencies in the operation of the systems.
- Ensuring that shifts are manned efficiently by providing adequate trained and licensed manpower.

- Bringing to the notice of SD/ CS/ TSS, promptly all deviations of Technical Specifications and all unusual occurrences with full information along with his comments and recommendations.
- Arrange to convene SORC meeting at least once in a month and also as and when necessary.
- Upkeep and updating of operating manuals.

MAINTENANCE SUPERINTENDENT (MS) is responsible for:

- Planned preventive / breakdown maintenance in respect of mechanical, electrical, control and fuel handling equipment / systems.
- Maintenance of adequate spares and consumables.
- Modifications to systems after approval by concerned authorities.
- Civil and Service maintenance.

TRAINING SUPERINTENDENT (TS) is responsible for coordinating arrangements for:

- Training of station staff in radiation protection, first aid and emergency procedures, industrial safety & fire protection.
- Training / Qualification / Re-qualification of operation staff.
- Training / Qualification / Re-qualification of maintenance staff.
- Training / Qualification / Re-qualification of fuel handling staff.

SUPERINTENDENT (QA) Heads the Quality Assurance group and is responsible for:

- Station Quality Assurance.
- Technical Audit.
- QA documentation.
- Monitoring the implementation status of recommendations of AERB.
- Pre-Service & In-service inspections.

Radiological Safety Officer (RSO) is responsible for advising station management and staff on radiation protection. This includes advice on personnel exposure, radiation monitoring and surveys and for liaison with Waste Management Plant regarding discharges and management of radioactive wastes, equipment for radiation protection and emergency arrangements and environmental surveys within the boundary of the unit. He is responsible for making measurements and observations during normal operations as well as during abnormal occurrences in the area of radiation safety.

SHIFT CHARGE ENGINEER (SCE) is responsible for authorizing all operation and maintenance activities of the station on shift basis. He is delegated all powers given to the SD / CS to maintain reactor systems under safe condition during operation and shutdown of the reactor. He is responsible for safe start up, operation and shutdown of the reactor, turbo generator and auxiliaries. In the absence of SCE, Assistance Shift Charge Engineer (ASCE) discharges these responsibilities. Both SCE and ASCE hold license issued by AERB for plant operation, including authorization for control panel operations.

REVIEW MECHANISM

TECHNICAL SERVICES SECTION at each station is entrusted with the responsibility of review of operational and safety performance of all the systems on a routine basis, identify areas for improvement and suggest necessary corrective actions. TSS, the head of the unit maintains liaison with unit safety committee and SARCOP. He also submits all safety related proposals for multi-tier review to SORC, NPC-SRC, unit safety committee and SARCOP for obtaining necessary approvals.

STATION OPERATION REVIEW COMMITTEE (SORC), headed by Station Director / Chief

Superintended and having TSS, MS, OS, Superintendent QA and Radiological Safety Officer as members is formed at each station. The committee,

- Reviews the station operations at regular intervals to detect potential safety issues at the station and recommends corrective actions.
- Reviews all proposed special / emergency operation, maintenance and test procedures and recommends revisions thereto as necessary.
- Reviews reactor shut downs initiated by safety system and recommends action to prevent recurrence of unwarranted shutdowns, where applicable.
- Reviews all proposed changes, Engineering Change Notices including modifications to approved procedures for plant systems / equipments and recommends action. The review includes an evaluation of the effect of the proposed change on the relevant technical specifications.
- Reviews all proposed changes to technical specifications / Station Policies and gives recommendation.
- Investigates promptly, all safety related unusual occurrences and instances involving deviations of technical specifications, station policies (as applicable).
- Investigates loss, misplacement or unauthorized use of radiation sources.
- Investigates incidents involving radioactive material during transportation within the controlled area of the station.
- Investigates incidents involving disabling injury preventing the person from working for a period of 24 hours or more. (Injuries of lesser significance are reviewed by Head. Fire & Industrial Safety).

TECHNICAL AUDIT ENGINEER is responsible for auditing and monitoring the compliance with the operating procedures, administrative procedures, surveillance test schedules, SORC recommendations, in-service inspection and Engineering Change Notices of all safety related systems. He also monitors deviations of the technical specifications & station policy, and follows up implementation of the decisions given by SORC / Unit Safety Committee / SARCOP from time to time.

OVER EXPOSURE INVESTIGATION COMMITTEE is constituted at each station to review all cases of radiation exposure above the investigation level, identify root causes and recommend remedial measures to prevent re-occurrence. The functions of the committee are:

- To investigate genuineness of the reported value in case of external exposure and measured value in case of internal exposure.
- To investigate fully, the causes of the over exposure and to prepare a factual report.
- To suggest remedial measures to prevent recurrence of such overexposures.
- To suggest further action in respect of work to be allocated to such over exposed persons.

Investigation by the committee is carried out within specified timeframe and the report is forwarded to Unit Safety Committee / SARCOP.

NPC-SRC (OPERATIONS)is the corporate level safety committee, with representation from design, safety, operation and quality assurance groups at NPCIL head quarter. All safety related proposals, including engineering changes, which require review and concurrence by regulatory body are first reviewed in NPC-SRC (operations). The recommendations made by this committee are incorporated before the proposal is forwarded to unit safety committee / Safety Review Committee for operating plants (SARCOP) at AERB.

Annex 19-2: Organization Chart of a Typical Indian Nuclear Power Plant